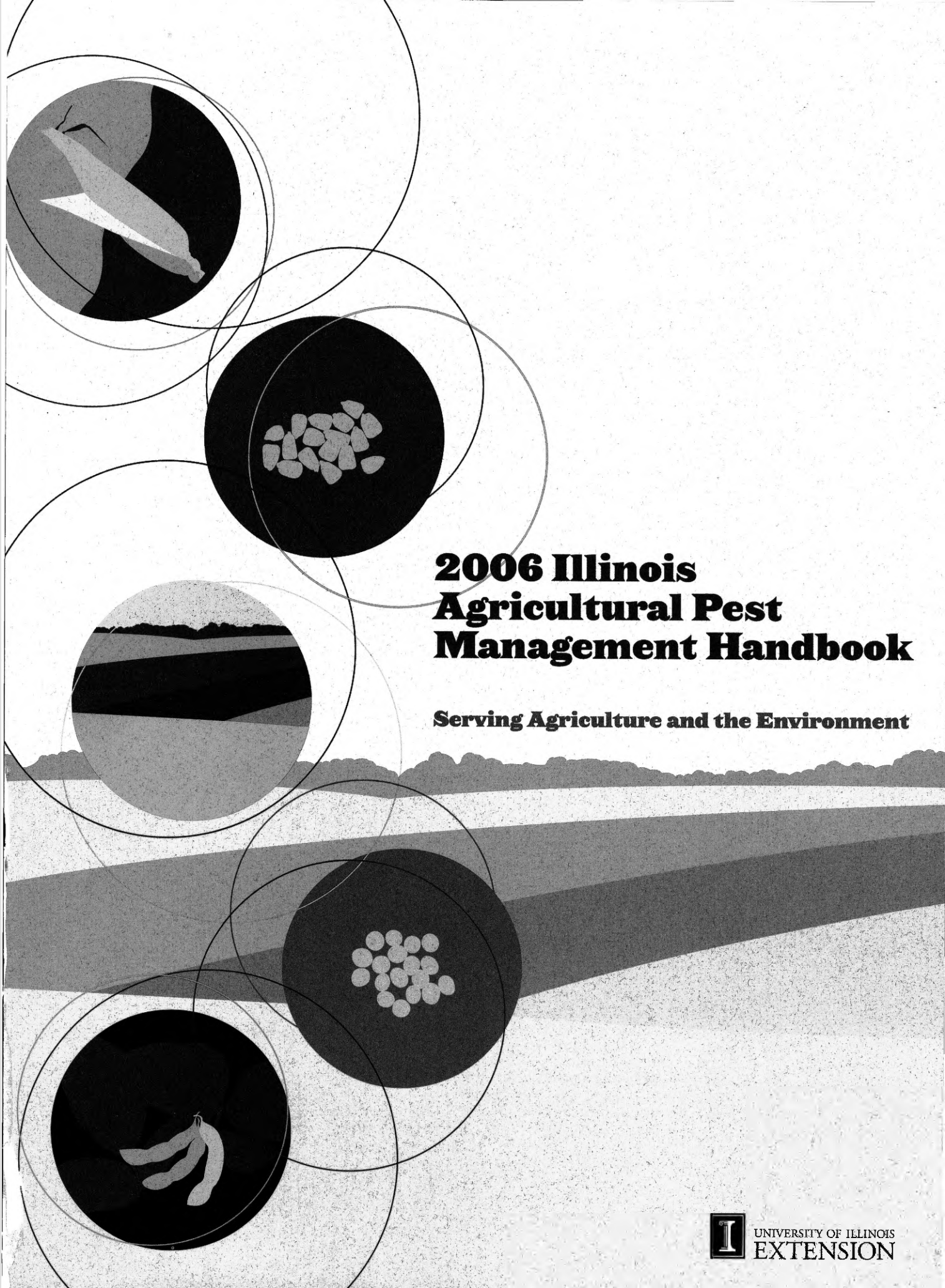

# 2006 Illinois Agricultural Pest Management Handbook

## Serving Agriculture and the Environment

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EXTENSION

The information in this handbook was prepared by specialists employed by the University of Illinois at Urbana-Champaign, College of Agricultural, Consumer and Environmental Sciences; and University of Illinois Extension. The information is revised extensively every year. **Because laws, regulations, pest-management practices, and pest-control products change significantly from year to year, out-of-date copies of this handbook may contain recommendations that are no longer legal or appropriate for the current calendar year.** The suggestions in this handbook should be used during 2006 only.

University of Illinois Extension assumes no liability for the recommendations for using pesticides that are included in this handbook. These recommendations are incomplete; therefore, they should be used only as guidelines. Complete instructions for the use of a specific pesticide are on the pesticide label. Read and follow the label directions and precautions before applying any pesticides. The pesticide user is responsible for applying pesticides according to label directions, as well as for problems that may arise through misapplication or misuse of the pesticide.

Not all pesticides registered for crop pests are included in this handbook. Effective pesticides that do not present an undue hazard to the user and the environment are suggested whenever possible. Trade names have been used for clarity, but their use does not constitute an endorsement by the University of Illinois, nor does it imply discrimination against other products.

Label changes, product cancellations, and changes in recommendations may have occurred since the publication of this handbook. Check with your nearest Extension office if you are in doubt about a pesticide that you plan to use. Announcement of new registrations, label changes, and changes in recommendations will be made through newsletters and appropriate media sources.

UNIVERSITY OF ILLINOIS
EXTENSION

College of Agricultural, Consumer and Environmental Sciences

College of Agricultural, Consumer and Environmental Sciences
University of Illinois at Urbana-Champaign

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# Acknowledgments

The compilation and publication of this handbook require considerable coordination and cooperation among several units in the College of Agricultural, Consumer and Environmental Sciences at the University of Illinois at Urbana-Champaign. Without the dedication of the individuals involved in this effort, the handbook could never be published. The following people worked with authors to produce the *2006 Illinois Agricultural Pest Management Handbook*.

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# Contents

# Insect Pest Management for Field and Forage Crops

This chapter addresses pest-management guidelines for insects that attack Illinois field and forage crops. Practical, nonchemical control measures that have proven effective are strongly encouraged. However, insecticides often are the only efficient tool for responding to insect pest outbreaks. We recommend that insecticides be used only to supplement a completely integrated pest management (IPM) program that also includes the use of multiple control tactics.

The insect-management guidelines provided in this chapter are based upon research results from the University of Illinois, College of Agricultural, Consumer, and Environmental Sciences, other land-grant universities, and the U.S. Department of Agriculture. The information in the handbook is revised annually and is intended for use during the current calendar year only.

The insect-control products suggested for use here have been registered by the U.S. Environmental Protection Agency (USEPA). However, not all products registered for control of crop insect pests are included. *Effective insect-control products that do not present an undue hazard to the user or the environment are suggested whenever possible.*

When this publication was prepared, only currently registered products were included. New registrations and changes in registration, labels, and recommendations will be announced through the *Pest Management & Crop Development Bulletin*, appropriate media sources, and Extension educators.

Some generic insecticides are formulated or sold by numerous pesticide formulations and distributors. These include bifenthrin, carbaryl, chlorpyrifos, dimethoate, and tebupirimphos. However, names and formulations of these generic insecticides are diverse, so their inclusion in this chapter is limited. The most commonly available trade name and formulation of each insecticide are included in this chapter. This practice does not represent discrimination against other trade names and formulations of the same product. Producers are advised to discuss the availability of generic products with a pesticide dealer.

Insect-control products suggested for use in field and forage crops are listed in Tables 1 to 9. Information regarding use rates and placement and timing of applications, as well as supportive comments, also is provided in the tables.

Directions for use, precautionary statements, and environmental and health hazards associated insecticides have become increasingly complex and detailed, and such information changes frequently. Consequently, we have not provided this type of information in this chapter. However, it is important that you obtain the most current information regarding insecticides either from the manufacturers or from comprehensive publications. The *Farm Chemicals Handbook*, published by Meister Publishing Company, Willoughby, Ohio, is an excellent reference for detailed and up-to-date information about all farm chemicals, including insecticides. The *Crop Protection Reference*, published by Chemical & Pharmaceutical Press, Inc., New York, New York, is another comprehensive publication that contains current labels for most registered pesticides. Information from this publication is also available on the Web at http://www.greenbook.net. Labels of pesticides available from many companies also can be accessed from the home page of Crop Data Management Systems, Inc., http://www.cdms.net.

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

## Additional Resources for Information About Insect Pests of Field and Forage Crops

The information provided in this chapter is intended primarily for individuals who make insect-control decisions during the growing season, which usually means application of an insecticide after scouting indicates the density of an insect has reached or exceeded an economic threshold. The guidelines in this chapter are complemented by many other resources that provide more detailed information about specific insects and their management.

In past volumes of this handbook, we provided considerable information about key insect pests of corn and soybeans—biology, scouting procedures, management guidelines. However, many of these aspects of insect management are dynamic, often changing within a given growing season. So this type of information about corn rootworms, European corn borers, belowground insect pests, bean leaf beetles, soybean aphids, and western bean cutworms is suitable for dissemination over the Internet, allowing for revisions and updates. You can access this information from the University of Illinois IPM Web site, http://www.ipm.uiuc.edu. During the growing season, time-sensitive information about pest management and crop development is published weekly in the *Pest Management & Crop Development Bulletin* (printed newsletter) and weekly or more frequently in *the Bulletin* on the Web, http://www.ipm.uiuc.edu/bulletin.

Descriptions and life cycles of the major pests, scouting procedures, and nonchemical control tactics also are important for development of a completely integrated insect management program. More detailed discussions of scouting procedures and economic thresholds are published in the *Field Crop Scouting Manual* (University of Illinois) and in *Corn Insect Pests—A Diagnostic Guide* (University of Missouri and University of Illinois). Both publications include color photographs and discussions of life cycles. The *Field Crop Scouting Manual* is available in both print and CD format, and *Corn Insect Pests A Diagnostic Guide* can be viewed on the Web at http://www.ipm.uiuc.edu/pubs/cip/pdf. More information about nonchemical management tactics and detailed information about the key insect pests of alfalfa, corn, soybeans, and wheat are discussed in the *Field Crop Scouting Manual.*

Information about the University of Illinois publications is available from your nearest Extension office or from Information Technology and Communication Services, Marketing and Distribution, 1917 S. Wright St., Champaign, IL 61820; (217)333-2007 or (800)345-6087; or online at http://www.publicationsplus.uiuc.edu.

The Entomological Society of America (ESA) has published comprehensive handbooks about soybean and corn insects. For information about the *Handbook*

**Table 1. Registered transgenic products for field corn**

| Product | Insecticidal protein | Controls . . . |
|---|---|---|
| YieldGard Corn Borer | Cry 1Ab | European corn borer, southwestern corn borer (also offers suppression of corn earworm, fall armyworm, stalk borer) |
| YieldGard Rootworm | Cry 3Bb1 | Northern, western, and Mexican corn rootworms |
| YieldGard Plus | Cry 1Ab + Cry 3Bb1 | European corn borer; southwestern corn borer; and northern, western, and Mexican corn rootworms (also offers suppression of corn earworm, fall armyworm, stalk borer) |
| Herculex I Insect Protection | Cry 1F | European corn borer, southwestern corn borer, black cutworm, western bean cutworm, fall armyworm (also offers suppression of corn earworm) |
| Herculex RW | Cry34Ab1 + Cry35Ab1 | Northern, western, and Mexican corn rootworms |
| Herculex XTRA | Cry1F + Cry34/35AB1 | European corn borer; southwestern corn borer; black cutworm; western bean cutworm; fall armyworm; and northern, western, and Mexican corn rootworms (also offers suppression of corn earworm) |

*of Soybean Insect Pests* and the *Handbook of Corn Insects*, call ESA headquarters, (301)731-4535, or e-mail sales@entoc.org. You can order the books from ESA's Web site, http://www.entsoc.org/pubs/books/handbooks.

## Recommended Web Resources

The Internet provides access to a multitude of informational sites that focus on management of pests. Following are a few relevant Web sites that provide very useful and timely information:

**http://www.ipm.uiuc.edu/**
University of Illinois IPM site

**http://www.ipm.uiuc.edu/bulletin**
*The Bulletin.* Pest management information throughout the growing season. Searchable.

**http://www.greenbook.net**
Excellent site for current pesticide labels and material safety data sheets

**http://www.cdms.net**
An excellent index of chemical companies involved in agriculture, with links to companies' Web sites. Searchable by product or brand.

Land-grant universities in the north-central states issue weekly newsletters during the growing season with some focus on insect pests of field and forage crops, as well as on plant diseases and weeds. Following are the Web addresses for these newsletters.

Indiana (Purdue University):
**http://www.entm/purdue.edu/entomology/ext/targets/newslett.htm**

Iowa State University:
**http://www.ipm.iastate.edu/ipm/icm**

Kansas State University:
**http://www.oznet.ksu.edu/entomology/extension/KIN/KIN_current.htm**

Kentucky, University of:
**http://www.uky.edu/Agriculture/kpn/kpnhome.htm**

Michigan State University:
**http://www.ipm.msu.edu/fieldCAT.htm**

Missouri, University of:
**http://ipm.missouri.edu/ipcm**

Nebraska, University of:
**http://cropwatch.unl.edu**
North Dakota State University:
**http://www.ag.ndsu.nodak.edu/aginfo/entomology/ndsucpr**

Ohio State University:
**http://corn.osu.edu**

South Dakota State University:
**http://plantsci.sdstate.edu/ent/entpubs/SEE_mail.htm**

Wisconsin, University of:
**http://ipcm.wisc.edu/wcm**

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**Table 2. Soil insecticides for rootworm control in Illinois**

| Insecticide | Time of application | Oz of product/ 1,000 ft of row | Amount of product per acre[a] | | | |
|---|---|---|---|---|---|---|
| | | | 40" rows | 38" rows | 36" rows | 30" rows |
| *Aztec 2.1%G | At planting | 6.7 | 5.5 lb | 5.8 lb | 6.1 lb | 7.3 lb |
| *Aztec 4.67G[b] | At planting | 3 | 2.45 lb | 2.58 lb | 2.72 lb | 3.27 lb |
| *Capture 2EC | At planting | 0.3 | 3.9 oz | 4.1 oz | 4.4 oz | 5.12 oz |
| *Force 3G | At planting or cultivation | 4–5 | 3.3–4.1 lb | 3.4–4.3 lb | 3.6–4.5 lb | 4.4–5.5 lb |
| *Fortress 2.5G | At planting | 6–9 | 4.9–7.4 lb | 5.2–7.8 lb | 5.5–8.2 lb | 6.5–9.8 lb |
| *Fortress 5G[b] | At planting | 3–4.5 | 2.5–3.7 lb | 2.6–3.9 lb | 2.8–4.1 lb | 3.3–4.9 lb |
| *Furadan 4F | At cultivation | 2.5 | 2 pt | 2⅛ pt | 2¼ pt | 2¾ pt |
| *Lorsban 4E | At planting or cultivation | 2.4 | 2 pt | 2.1 pt | 2.2 pt | 2.6 pt |
| Lorsban 15G | At planting or cultivation | 8 | 6.5 lb | 6.9 lb | 7.3 lb | 8.7 lb |

*Use restricted to certified applicators.
[a]Do not exceed the following amounts of specific products per acre per season: 7.3 lb of Aztec 2.1%G; 3.27 lb of Aztec 4.67G; 0.3 lb active ingredient (includes planting and foliar applications) of Capture 2EC; 5.5 lb of Force 3G; 13.5 lb of Lorsban 15G.
[b]Aztec 4.67G and Fortress 5G are available only in the SmartBox closed handling and application system.

**Table 3. Insecticides for field corn**

| Insect | Insecticide[a] | Amount of product[a] per acre or per 1,000 ft row (where indicated) | Placement | Timing of application, comments |
|---|---|---|---|---|
| Armyworm | *Ambush 25W | 6.4 to 12.8 oz | Broadcast | *Seedling corn*: Control may be justified when 25% of the plants are being damaged. *After pollen shed*: Control may be justified when armyworms are eating leaves above ear level. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | Intrepid 2F | 4 to 8 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 3.2 to 4 oz | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | Sevin XLR Plus | 1 to 2 qt | | |
| | Tracer 4SC | 1 to 3 oz | | |
| Billbugs | *Lorsban 4E | 2 to 3 pt | Spray at base of plant or over row | Apply as a postemergence rescue treatment. Use only ground equipment, and apply 20 to 40 gallons of finished spray per acre. |
| Chinch bug | *Asana XL | 5.8 to 9.6 oz | Spray at base of plant | Treat border rows at the start of migration from small grains. Use only ground equipment. |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 3.2 to 4 oz | | |
| | *Proaxis | 3.84 oz | | |
| | Sevin XLR Plus | 1 to 2 qt | | |
| | *Warrior | 3.84 oz | | |

**Table 3. Insecticides for field corn (cont.)**

| Insect | Insecticide[a] | Amount of product[a] per acre or per 1,000 ft row (where indicated) | Placement | Timing of application, comments |
|---|---|---|---|---|
| Corn earworm | *Ambush 25W | 6.4 to 12.8 oz | Overall spray or directed toward ear zone | Treatment is justified only in seed-corn fields. Treatments are rarely effective for the control of earworms after worms enter ear tips. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Tracer 4SC | 2 to 3 oz | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| Corn leaf aphid | *Capture 2EC | 2.1 to 6.4 oz | Broadcast | Apply during late whorl to early tassel when 50% of plants have light to moderate infestations (50 to 400 aphids per plant) and plants are under drought stress. If soil moisture is adequate, treatment may be warranted if there are more than 400 aphids per plant. Do not apply dimethoate to corn during the pollen-shed period. |
| | Dimethoate 4EC | ⅔ to 1 pt | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Penncap-M | 2 to 3 pt | | |
| Corn rootworm adults | *Ambush 25W | 6.4 to 12.8 oz | Overall spray or directed toward ear zone | To protect pollination, treat if there are 5 or more beetles per plant, pollination is not complete, and silk clipping is observed. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | Dimethoate 4EC | ⅔ to 1 pt | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Penncap-M | 1 to 2 pt | | |
| | *Pounce 3.2 EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Sevin XLR Plus | 1 to 2 qt | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Corn rootworm larvae | *Aztec 2.1%G | 6.7 oz/1,000 ft row | Band,[b] furrow | At planting. To minimize potential adverse effects to wildlife, incorporate insecticide granules or apply the insecticide in-furrow (if labeled) and shut off insecticide units in turn rows. For more information on insecticide rates and timing of insecticide applications, refer to Table 2. |
| | *Aztec 4.67G[c] | 3 oz/1,000 ft row | Band,[b] furrow | |
| | *Capture 2EC | 0.3 oz/1,000 ft row | Band[b] | |
| | *Force 3G | 4 to 5 oz/1,000 ft row | Band,[b] furrow | |
| | *Fortress 2.5G | 6 to 9 oz/1,000 ft row | Furrow | |
| | *Fortress 5G[c] | 3 to 4.5 oz/1,000 ft row | Furrow | |
| | *Lorsban 4E | 2.4 fl oz/1,000 ft row | Band[b] | |
| | Lorsban 15G | 8 oz/1,000 ft row | Band[b] | |
| | Cruiser | See product label. | On seed | Select hybrids treated with Criuser or Poncho 1250. |
| | Poncho 1250 | See product label. | On seed | |

**Table 3. Insecticides for field corn (cont.)**

| Insect | Insecticide[a] | Amount of product[a] per acre or per 1,000 ft row (where indicated) | Placement | Timing of application, comments |
|---|---|---|---|---|
| Cutworms[d] | *Ambush 25W | 6.4 to 12.8 oz | Broadcast | Apply as a postemergence rescue treatment when 3 to 5% or more of the plants are cut and larvae are present. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 0.8 to 1.6 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 1.28 to 2.8 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| European corn borer, first generation | *Ambush 25W | 6.4 to 12.8 oz | Broadcast | Use "Management Worksheet for First-Generation European Corn Borer" to aid in decision making (http://www.ipm.uiuc.edu/decision/corn_borer_first.html). Granular formulations are more effective than sprays when applied by air for control of first-generation borers. Sprays are most effective when directed by ground equipment over the row rather than broadcast. |
| | *Bacillus thuringiensis* | See product label. | See product label. | |
| | *Baythroid 2 | 1.6 to 2.8 oz | Broadcast | |
| | *Capture 2EC | 2.1 to 6.4 oz | Broadcast | |
| | *Empower 2 | 3.5 to 8.7 lb | Broadcast | |
| | Intrepid 2F | 4 to 8 oz | Broadcast | |
| | *Lorsban 4E | 1½ to 2 pt | Over whorls | |
| | *Lorsban 15G | 3.5 to 8 oz/1,000 ft row | Over whorls | |
| | Lorsban 15G | 5 to 6.5 lb | Broadcast | |
| | *Mustang Max | 2.72 to 4 oz | Broadcast | |
| | *Penncap-M | 2 pt | Over whorls | |
| | *Penncap-M | 3 to 4 pt | Broadcast | |
| | *Pounce 1.5G | 6.7 to 13.3 lb | Broadcast | |
| | *Pounce 3.2EC | 4 to 8 oz | Broadcast | |
| | *Proaxis | 2.56 to 3.84 oz | Broadcast | |
| | Tracer 4SC | 1 to 3 oz | Broadcast | |
| | *Warrior | 2.56 to 3.84 oz | Broadcast | |
| European corn borer, second generation | *Ambush 25W | 6.4 to 12.8 oz | Broadcast | Use "Management Worksheet for Second-Generation European Corn Borer" to aid in decision making (http://www.ipm.uiuc.edu/decision/corn_borer_second.html). |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | Intrepid 2F | 4 to 8 oz | | |
| | Lorsban 4E | 1½ to 2 pt | | |
| | Lorsban 15G | 6.5 lb | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Penncap-M | 2 to 4 pt | | |
| | *Pounce 1.5G | 6.7 to 13.3 lb | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Tracer 4SC | 1 to 3 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Fall armyworm | *Ambush 25W | 6.4 to 12.8 oz | Broadcast | Treat when 75% of plants have whorl damage and if worms are present. Ground sprays directed over the row are more effective than broadcast sprays. Treatments to control worms in ear tips are not effective. |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Empower 2 | 3.5 to 8.7 lb | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 3.2 to 4 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | Tracer 4SC | 1 to 3 oz | | |

**Table 3. Insecticides for field corn (cont.)**

| Insect | Insecticide[a] | Amount of product[a] per acre or per 1,000 ft row (where indicated) | Placement | Timing of application, comments |
|---|---|---|---|---|
| Flea beetles | *Ambush 25W | 6.4 to 12.8 oz | Over row as spray | Treat when leaves on seedling plants are severely damaged and plants are being killed. For Lorsban, use only ground equipment and apply 20 to 40 gallons of finished spray per acre. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Sevin XLR Plus | 1 to 2 qt | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Grasshoppers | *Asana XL | 5.8 to 9.6 oz | Broadcast | Treatment may be warranted when there are 7 or more grasshoppers per square yard. After pollen shed, control may be justified when grasshoppers are feeding on leaves above ear level. Do not apply dimethoate to corn during the pollen-shed period. |
| | *Baythroid 2 | 2.1 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | Dimethoate 4EC | 1 pt | | |
| | *Lorsban 4E | ½ to 1 pt | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Sevin XLR Plus | ½ to 1½ qt | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Hop vine borer | *Mustang Max | 2.72 to 4 oz | Broadcast | Apply postemergence sprays when young larvae are moving from weed hosts into corn. |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Japanese beetle (adult) | *Baythroid 2 | 1.6 to 2.8 oz | Broadcast | Treat during tasseling and silking if there are 3 or more beetles per ear and pollination is not complete. |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Penncap-M | 2 to 4 pt | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.46 to 3.84 oz | | |
| | Sevin XLR Plus | 1 to 2 qt | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Picnic, sap beetles | *Capture 2EC | 2.1 to 6.4 oz | Broadcast | Treatment is justified only in seed-corn fields when beetles are causing significant injury to ear tips. |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Sevin XLR Plus | 1 to 2 qt | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Seedcorn maggot | Cruiser | See product label. | On seed | Use formulations that are prepared as seed treaters, or select hybrids treated with Cruiser or Poncho. Seed treatments should be considered for fields that do not receive a soil insecticide at planting. See label for proper disposal of treated seeds. |
| | diazinon | See product label. | On seed | |
| | diazinon + lindane | See product label. | On seed | |
| | imidacloprid | See product label. | On seed | |
| | permethrin | See product label. | On seed | |
| | Poncho | See product label. | On seed | |

**Table 3. Insecticides for field corn (cont.)**

| Insect | Insecticide[a] | Amount of product[a] per acre or per 1,000 ft row (where indicated) | Placement | Timing of application, comments |
|---|---|---|---|---|
| Southern corn leaf beetle | *Baythroid 2 | 1.6 to 2.8 oz | Broadcast | Apply as a postemergence rescue treatment. |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Warrior | 3.84 oz | | |
| Southwestern corn borer, second generation | *Ambush 25W | 6.4 to 12.8 oz | Broadcast | Treatment may be warranted when 20 to 25% of the plants are infested with eggs or newly hatched larvae. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Empower 2 | 3.5 to 8.7 lb | | |
| | Intrepid 2F | 4 to 8 oz | | |
| | *Lorsban 4E | 1½ to 2 pt | | |
| | Lorsban 15G | 6.5 lb | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Penncap-M | 2 to 4 pt | | |
| | *Pounce 1.5G | 6.7 to 13.3 lb | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Tracer 4SC | 2 to 3 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Spider mites | *Capture 2EC | 5.12 to 6.4 oz | Broadcast | Begin control if the majority of plants are infested with mites severely enough to cause some yellowing or browning of the lower leaves before dent stage. Do not apply dimethoate to corn during the pollen-shed period. |
| | Dimethoate 4EC | ⅔ to 1 pt | | |
| Stalk borer | *Ambush 25W | 6.4 to 12.8 oz | Broadcast | Apply postemergence sprays when young larvae are moving from weed hosts to corn. See labels for more specific instructions about effective control. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Lorsban 4E | 2 to 3 pt | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Stink bugs | *Baythroid 2 | 1.6 to 2.8 oz | Broadcast | Apply as postemergence rescue treatment. |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Penncap-M | 1 to 3 pt | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |

**Table 3. Insecticides for field corn (cont.)**

| Insect | Insecticide[a] | Amount of product[a] per acre or per 1,000 ft row (where indicated) | Placement | Timing of application, comments |
|---|---|---|---|---|
| Webworms | *Baythroid 2 | 1.6 to 2.8 oz | Broadcast | For Lorsban, shallow incorporation using a rotary hoe or other suitable equipment immediately before or soon after treatment is necessary. |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.72 to 4 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Western bean cutworm | *Asana XL | 2.9 to 5.8 oz | Broadcast | Treatment may be warranted when 8% of plants have egg masses and/or small larvae. |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Capture 2EC | 2.1 to 6.4 oz | | |
| | Intrepid | 4 to 8 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 1.76 to 4 oz | | |
| | *Penncap-M | 2 to 4 pt | | |
| | *Pounce 3.2 EC | 2 to 4 oz | | |
| | *Proaxis | 1.92 to 3.20 oz | | |
| | Sevin XLR Plus | 2 qt | | |
| | Tracer 4SC | 2 to 3 oz | | |
| | *Warrior | 1.92 to 3.20 oz | | |
| White grubs | *Aztec 2.1%G | 6.7 oz/1,000 ft row | Band,[b] furrow | Treat if crop history and previous crop losses can be directly linked to a repeated history of grub problems. To minimize potential adverse effects to wildlife, incorporate insecticide granules or apply the insecticide in-furrow (if labeled) and shut off insecticide units in turn rows. |
| | *Aztec 4.67G[c] | 3 oz/1,000 ft row | Band,[b] furrow | |
| | *Capture 2EC | 0.15 to 0.3 oz/1,000 ft row | Band,[b] furrow | |
| | *Capture 2EC | 3 to 4 oz | BC-PPI[e] | |
| | *Empower 2 | 3.2 to 8 oz/1,000 ft row | Band,[b], furrow | |
| | *Force 3G | 4 to 5 oz/1,000 ft row | Furrow | |
| | *Fortress 2.5G | 6 to 7.5 oz/1,000 ft row | Furrow | |
| | *Fortress 5G[c] | 3 to 3.75 oz/1,000 ft row | Furrow | |
| | *Lorsban 4E | 4 pt | BC-PPI[e] | |
| | Lorsban 15G | 8 oz/1,000 ft row | Band,[b] furrow | |
| | *Proaxis | 0.66 oz/1,000 ft | Furrow | |
| | *Regent 4SC | row | Furrow | |
| | | 0.24 oz/1,000 | | |
| | *Warrior | ft row | Band[b] | |
| | | 0.66 oz/1,000 ft row | | |
| | Cruiser | See product label. | On seed | Select hybrids treated with Cruiser or Poncho. |
| | Poncho | See product label. | On seed | |

**Table 3. Insecticides for field corn (cont.)**

| Insect | Insecticide[a] | Amount of product[a] per acre or per 1,000 ft row (where indicated) | Placement | Timing of application, comments |
|---|---|---|---|---|
| Wireworms | *Aztec 2.1%G | 6.7 oz/1,000 ft row | Band,[b] furrow | Treat at planting if crop history or bait stations or both indicate a potential for wireworm damage. To minimize potential adverse effects to wildlife, incorporate insecticide granules or apply the insecticide in-furrow (if labeled) and shut off insecticide units in turn rows. |
| | *Aztec 4.67G[c] | 3 oz/1,000 ft row | Band,[b] furrow | |
| | *Capture 2EC | 0.15 to 0.3 oz/1,000 ft row | Band,[b] furrow | |
| | *Capture 2EC | 3 to 4 oz | BC-PPI[e] | |
| | *Empower 2 | 3.2 to 8 oz/1,000 ft row | Band,[b] furrow<br>Furrow | |
| | *Force 3G | 4 to 5 oz/1,000 ft row | | |
| | *Fortress 2.5G | 6 to 7.5 oz/1,000 ft row | Furrow | |
| | *Fortress 5G[c] | 3 to 3.75 oz/1,000 ft row | Furrow | |
| | *Lorsban 4E | 4 pt | BC-PPI[e] | |
| | Lorsban 15G | 12 oz/1,000 ft row | Furrow | |
| | *Pounce 1.5G | 8 to 16 oz/1,000 ft row | Furrow | |
| | *Pounce 3.2EC | 0.3 oz/1,000 ft row | Furrow | |
| | *Regent 4SC | 0.24 oz/1,000 ft row | Furrow | |
| | *Warrior | 0.66 oz/1,000 ft row | Band,[b] furrow | |
| | Cruiser | See product label. | On seed | Use formulations that are prepared as seed treaters, or select hybrids treated with Cruiser or Poncho. See label for proper disposal of treated seeds. |
| | diazinon + lindane | See product label. | On seed | |
| | imidacloprid | See product label. | On seed | |
| | lindane | See product label. | On seed | |
| | permethrin | See product label. | On seed | |

*Use restricted to certified applicators.

[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

[b]Band = band over the row, or T-band over an open seed furrow. Refer to product label for specific information and band width.

[c]Aztec 4.67G and Fortress 5G are available only in the SmartBox closed handling and application system.

[d]We recommend that cutworms should be managed with a program of regular scouting and the use of insecticides only if densities of cutworms exceed established economic thresholds. There are many products (soil insecticides, insecticidal seed treatments, transgenic Bt hybrids) labeled for various levels of prevention of cutworm injury. These products include, but are not limited to, Ambush, Asana, Aztec, Capture, Cruiser, Empower, Force, Fortress, corn hybrids with Herculex insect protection, Lorsban, Mustang Max, Poncho, Pounce, Warrior, and YieldGard Corn Borer hybrids. Consult with your chemical company representative to determine appropriate insecticide formulations and rates and timing of application. Consult with your seed company representative to determine hybrids with insecticidal seed treatments or with transgenic *Bt* traits.

[e]BC-PPI = broadcast–preplant incorporated.

**Table 4. Insecticides for soybeans**

Spraying blossoming soybeans can be extremely hazardous to bees. Coordinate with local beekeepers before applying sprays. Beekeepers' names and colony locations may be obtained from your local Extension office.

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Bean leaf beetle | *Ambush 25W | 3.2 to 6.4 oz | On foliage | *Seedlings:* An insecticide treatment for seedling soybeans is rarely justified. Densities of 16 per foot of row in the early seedling stage or 39 per foot of row at stage V2+ are necessary for economic injury. *Before bloom:* Treat when defoliation reaches 30% and there are 5 or more beetles per foot of row. *Bloom to pod fill:* Economic thresholds for bean leaf beetles feeding on R5–R6 soybeans vary depending on the cost of treatment and the value of soybeans. *Seed maturation:* Treat when 5 to 10% of the pods are damaged, the leaves are green, and there are 10 or more beetles per foot of row. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1 to 1.6 oz | | |
| | Dimethoate 4EC | 1 pt | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.8 to 4 oz | | |
| | Orthene 90S | 0.83 to 1.1 lb | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Pounce 3.2EC | 2 to 4 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Sevin XLR Plus | ½ to 1 qt | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| Blister beetles | *Baythroid 2 | 1.6 to 2.8 oz | On foliage | Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill. |
| | *Mustang Max | 2.8 to 4 oz | | |
| | *Proaxis | 3.2 to 3.84 oz | | |
| | Sevin XLR Plus | ½ to 1 qt | | |
| | *Warrior | 3.2 to 3.84 oz | | |
| Corn earworm | *Ambush 25W | 6.4 to 12.8 oz | On foliage | Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill, or when 5 to 10% of the pods are damaged. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Mustang Max | 2.8 to 4 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Tracer 4SC | 1.5 to 2 oz | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| Cutworms | *Asana XL | 5.8 to 9.6 oz | Broadcast | Scout as plants are emerging. Treat if 20% of plants are cut, stand has gaps of 1 foot or more, and cutworms are present. |
| | *Baythroid 2 | 0.8 to 1.6 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 1.28 to 4 oz | | |
| | *Pounce 3.2EC | 2 to 4 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| Grasshoppers | *Asana XL | 5.8 to 9.6 oz | On foliage | Treat when migration into fields begins and defoliation or pod feeding reaches economic levels; when defoliation reaches 30% before bloom and 20% between bloom and pod fill; when 5 to 10% of the pods are damaged. |
| | *Baythroid 2 | 2.1 to 2.8 oz | | |
| | Dimethoate 4EC | 1 pt | | |
| | *Lorsban 4E | ½ to 1 pt | | |
| | *Mustang Max | 3.2 to 4 oz | | |
| | Orthene 90S | 0.28 to 0.56 lb | | |

**Table 4. Insecticides for soybeans (cont.)**

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Grasshoppers (cont.) | *Penncap-M | 2 to 3 pt | | |
| | *Proaxis | 3.2 to 3.84 oz | | |
| | Sevin XLR Plus | ½ to 1½ qt | | |
| | *Warrior | 3.2 to 3.84 oz | | |
| Green cloverworm | *Ambush 25W | 3.2 to 6.4 oz | On foliage | Treat when defoliation occurs during blooming, pod set, and pod fill. Usually requires 12 or more half-grown worms per foot of row and 20% defoliation to justify treatment. |
| | *Asana XL | 2.9 to 5.8 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Lorsban 4E | ½ to 1 pt | | |
| | *Mustang Max | 2.8 to 4 oz | | |
| | Orthene 90S | 0.83 to 1.1 lb | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Pounce 3.2EC | 2 to 4 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Sevin XLR Plus | ½ to 1 qt | | |
| | Tracer 4SC | 1 to 2 oz | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| Japanese beetle adults | *Ambush 25W | 6.4 to 12.8 oz | On foliage | Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill. |
| | *Asana XL | 5.8 to 9.6 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Mustang Max | 2.8 to 4 oz | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Pounce 3.2EC | 2 to 4 oz | | |
| | *Proaxis | 3.2 to 3.84 oz | | |
| | Sevin XLR Plus | ½ to 1 qt | | |
| | *Warrior | 3.2 to 3.84 oz | | |
| Mexican bean beetle | *Ambush 25W | 3.2 to 6.4 oz | On foliage | Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill. |
| | *Asana XL | 2.9 to 5.8 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | Dimethoate 4EC | 1 pt | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.8 to 4 oz | | |
| | Orthene 90S | 0.83 to 1.1 lb | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Pounce 3.2EC | 2 to 4 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Sevin XLR Plus | ½ to 1 qt | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| Potato leafhopper | *Ambush 25W | 3.2 to 6.4 oz | On foliage | Treat when leafhoppers are numerous and the edges of the leaves appear burned. For susceptible varieties, control in blooming soybeans may be warranted when 6 or more leafhoppers are found per plant. During early seed formation, control may be warranted if 13 or more leafhoppers are found per plant. |
| | *Asana XL | 2.9 to 5.8 oz | | |
| | *Baythroid 2 | 0.8 to 1.6 oz | | |
| | Dimethoate 4EC | 1 pt | | |
| | *Mustang Max | 2.8 to 4 oz | | |
| | Orthene 90S | 0.56 to 1.1 lb | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Pounce 3.2EC | 2 to 4 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Sevin XLR Plus | 1 qt | | |
| | *Warrior | 1.92 to 3.2 oz | | |

**Table 4. Insecticides for soybeans (cont.)**

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Seedcorn maggot | Cruiser<br>lindane<br>permethrin | See product label.<br>See product label.<br>See product label. | On seed<br>On seed<br>On seed | Use formulations that are prepared as seed treaters. See label for proper disposal of treated seeds. |
| Soybean aphid | *Asana XL<br>*Furadan 4F<br>*Lorsban 4E<br>*Mustang Max<br>Orthene 90S<br>*Penncap-M<br>*Proaxis<br>*Warrior | 5.8 to 9.6 oz<br>¼ to ½ pt<br>1 to 2 pt<br>2.8 to 4 oz<br>0.56 to 1.1 lb<br>1 to 3 pt<br>1.92 to 3.2 oz<br>1.92 to 3.2 oz | On foliage | Treatment may be warranted if there are 250 or more aphids per plant at the R1 or R2 stage, plants show symptoms of injury, and few natural enemies are present. |
| Soybean looper | *Ambush 25W<br>*Mustang Max<br>*Penncap-M<br>*Pounce 3.2EC<br>Tracer 4SC | 6.4 to 12.8 oz<br>3.2 to 4 oz<br>2 to 3 pt<br>4 to 8 oz<br>1 to 2 oz | On foliage | Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill. |
| Spider mites | Dimethoate 4EC<br>*Lorsban 4E | 1 pt<br>1 to 2 pt | On foliage | Treat when 20 to 25% discoloration is noted before pod set, or 10 to 15% discoloration after pod set. |
| Stink bugs | *Asana XL<br>*Baythroid 2<br>*Lorsban 4E<br>*Mustang Max<br>Orthene 90S<br>*Penncap-M<br>*Proaxis<br>Sevin XLR Plus<br>*Warrior | 5.8 to 9.6 oz<br>1.6 to 2.8 oz<br>2 pt<br>3.2 to 4 oz<br>0.56 to 1.1 lb<br>1 to 3 pt<br>3.2 to 3.84 oz<br>1 to 1½ qt<br>3.2 to 3.84 oz | On foliage | Treat when adult bugs or large nymphs reach 1 per foot of row during pod fill. |
| Thistle caterpillar | *Mustang Max<br>*Pounce 3.2EC<br>Sevin XLR Plus<br>*Warrior | 1.28 to 4 oz<br>2 to 4 oz<br>1½ qt<br>1.92 to 3.2 oz | On foliage | Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill. |
| Thrips | *Baythroid 2<br>Orthene 90S<br>*Penncap-M<br>*Proaxis<br>Sevin XLR Plus<br>*Warrior | 0.8 to 1.6 oz<br>0.28 to 0.56 lb<br>2 to 3 pt<br>1.92 to 3.2 oz<br>1 qt<br>1.92 to 3.2 oz | On foliage | Treat if seedlings are being seriously damaged and some plants are being killed. |

**Table 4. Insecticides for soybeans (cont.)**

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Woollybear caterpillars | *Ambush 25W | 3.2 to 6.4 oz | On foliage | Treat when defoliation reaches 30% before bloom and 20% between bloom and pod fill. |
| | *Asana XL | 2.9 to 5.8 oz | | |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.8 to 4 oz | | |
| | *Pounce 3.2 EC | 2 to 4 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Sevin XLR Plus | 1½ qt | | |
| | Tracer 4SC | 1.5 to 2 oz | | |
| | *Warrior | 1.92 to 3.2 oz | | |

*Use restricted to certified applicators.
[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

**Table 5. Insecticides for alfalfa**

Spraying blossoming alfalfa can be extremely hazardous to bees. Coordinate with local beekeepers before applying sprays. Beekeepers' names and colony locations may be obtained from your local Extension office.

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Alfalfa blotch leafminer | *Baythroid 2 | 2 to 2.8 oz | On foliage | Specific economic thresholds have not been established in the Midwest. Treatment may be warranted if injury is severe. |
| | *Furadan 4F | 1 to 2 pt | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Proaxis | 3.84 oz | | |
| | Sevin XLR Plus | 1 to 1½ qt | | |
| | *Warrior | 3.84 oz | | |
| Alfalfa caterpillar | *Ambush 25W | 3.2 to 12.8 oz | On foliage | Treat when damage to foliage is obvious and there are at least 10 nonparasitized larvae per sweep. |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.24 to 4 oz | | |
| | *Pounce 3.2EC | 2 to 8 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Sevin XLR Plus | 1 qt | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| Alfalfa weevil larvae | *Ambush 25W | 12.8 oz | On foliage | When 25 to 50% of tips are being skeletonized and there are 3 or more larvae per stem, treat immediately. Do not apply sprays during bloom. Instead, cut and remove the hay. Two treatments may be necessary on first cutting. Control also may be warranted after a cutting when larvae and adults are feeding on more than 50% of the crowns and regrowth is prevented for 3 to 6 days. |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Furadan 4F | ½ to 2 pt | | |
| | Imidan 70W | 1 to 1⅓ lb | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.24 to 4 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |

**Table 5. Insecticides for alfalfa (cont.)**

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Alfalfa weevil adults | *Furadan 4F<br>Imidan 70W<br>*Lorsban 4E | 1 to 2 pt<br>1 to 1⅓ lb<br>1 to 2 pt | On foliage | Control may be warranted after a cutting when larvae and adults are feeding on more than 50% of the crowns and regrowth is prevented for 3 to 6 days. |
| Blister beetles | *Proaxis<br>Sevin XLR Plus<br>*Warrior | 2.56 to 3.84 oz<br>½ to 1 qt<br>2.56 to 3.84 oz | On foliage | Although blister beetles rarely cause economic damage to alfalfa, their presence in hay could injure horses if the horses ingest the beetles. |
| Cutworms | *Ambush 25W<br>*Baythroid 2<br>*Lorsban 4E<br>*Mustang Max<br>*Pounce 3.2EC<br>*Proaxis<br>*Warrior | 3.2 to 12.8 oz<br>0.8 to 1.6 oz<br>1 to 2 pt<br>2.24 to 4 oz<br>2 to 8 oz<br>1.92 to 3.2 oz<br>1.92 to 3.2 oz | On seedlings | Control may be warranted when larvae reduce the stand of a new seeding or prevent regrowth after harvest. |
| Fall armyworm | *Lorsban 4E<br>*Mustang Max<br>*Pounce 3.2EC | 1 to 2 pt<br>2.8 to 4 oz<br>2 to 8 oz | On seedlings | Control may be warranted when larvae reduce the stand of a new seeding, when there are 2 or more larvae per sweep, or when there are 1 to 2 half-grown larvae per square foot. |
| Grasshoppers | *Baythroid 2<br>Dimethoate 4EC<br>Imidan 70W<br>*Lorsban 4E<br>*Mustang Max<br>*Proaxis<br>Sevin XLR Plus<br>*Warrior | 2 to 2.8 oz<br>½ to 1 pt<br>1 to 1⅓ lb<br>½ to 1 pt<br>2.8 to 4 oz<br>2.56 to 3.84 oz<br>½ to 1½ qt<br>2.56 to 3.84 oz | On foliage | Treat when grasshoppers are small, before damage is severe, and when there are 15 to 20 per square yard. |
| Meadow spittlebug | *Ambush 25W<br>*Baythroid 2<br>Imidan 70W<br>*Lorsban 4E<br>*Mustang Max<br>*Pounce 3.2EC<br>*Proaxis<br>*Warrior | 6.4 to 12.8 oz<br>0.8 to 1.6 oz<br>1 to 1⅓ lb<br>1 to 2 pt<br>2.24 to 4 oz<br>4 to 8 oz<br>2.56 to 3.84 oz<br>2.56 to 3.84 oz | On foliage | Treat when spittle masses are found and nymphs average more than 1 per stem. |

**Table 5. Insecticides for alfalfa (cont.)**

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Plant bugs | *Ambush 25W | 6.4 to 12.8 oz | On foliage | Treat when tip damage is obvious and nymphs and adults average 3 per sweep on alfalfa less than 3 inches tall, or 5 per sweep on alfalfa taller than 3 inches. |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | Dimethoate 4EC | ½ to 1 pt | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 2.8 to 4 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Sevin XLR Plus | 1 to 1½ qt | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Potato leafhopper | *Ambush 25W | 3.2 to 12.8 oz | On foliage | Treatment is justified at these combinations of alfalfa height and leafhopper numbers: |
| | *Baythroid 2 | 0.8 to 1.6 oz | | |
| | Dimethoate 4EC | ½ to 1 pt | | |
| | Imidan 70W | 1 to 1⅓ lb | | |
| | *Lorsban 4E | ½ to 1 pt | | |
| | *Mustang Max | 2.24 to 4 oz | | |
| | *Pounce 3.2EC | 4 to 8 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Sevin XLR Plus | 1 qt | | |
| | *Warrior | 1.92 to 3.2 oz | | |
| Webworms | *Ambush 25W | 3.2 to 12.8 oz | On seedlings or foliage | Control may be warranted when larvae reduce the stand of a new seeding or when heavy infestations result in copious webbing. |
| | *Baythroid 2 | 1.6 to 2.8 oz | | |
| | *Mustang Max | 2.24 to 4 oz | | |
| | *Pounce 3.2EC | 2 to 8 oz | | |
| | *Proaxis | 1.92 to 3.2 oz | | |
| | Sevin XLR Plus | 1 to 1½ qt | | |
| | *Warrior | 1.92 to 3.2 oz | | |

| Alfalfa height (inches) | Leafhoppers per sweep |
|---|---|
| Under 3 | 0.2 |
| 3 to 6 | 0.5 |
| 6 to 12 | 1.0 |
| 12 or taller | 2.0 |

*Use restricted to certified applicators.
[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

**Table 6. Insecticides for grain sorghum**

| Insect | Insecticide[a,b] | Amount of product per acre[a,b] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Chinch bug | *Asana XL | 5.8 to 9.6 oz | At plant base | Direct spray toward base of plant. Use only ground equipment. |
| | *Baythroid 2 | 2 to 2.8 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 3.2 to 4 oz | | |
| | *Proaxis | 3.84 oz | | |
| | Sevin XLR Plus | 1 to 2 qt | | |
| | *Warrior | 3.84 oz | | |
| Corn earworm (headworm) | *Asana XL | 5.8 to 9.6 oz | Over row | Treat when worms average 2 or more per head. |
| | *Baythroid 2 | 1.3 to 2.8 oz | | |
| | *Mustang Max | 1.76 to 4 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Tracer 4SC | 1.5 to 3 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Corn leaf aphid | Dimethoate 4EC | ½ to 1 pt | Over row | Corn leaf aphids rarely cause economic damage unless populations are heavy and drought conditions exist. |
| | *Lorsban 4E | ½ to 1 pt | | |
| Cutworms | *Asana XL | 5.8 to 9.6 oz | Broadcase | Treat when seedling plants are being cut. |
| | *Baythroid 2 | 1 to 1.3 oz | | |
| | *Lorsban 4E | 1 to 2 pt | | |
| | *Mustang Max | 1.28 to 4 oz | | |
| | *Proaxis | 1.92 to 2.56 oz | | |
| | *Warrior | 1.92 to 2.56 oz | | |
| Fall armyworm | *Lorsban 4E | 1 to 2 pt | Over row | Treat when worms average 2 or more per head. Leaf feeding or whorl damage seldom has an economic effect. |
| | *Mustang Max | 1.76 to 4 oz | | |
| | Tracer 4SC | 1.5 to 3 oz | | |
| Grasshoppers | *Baythroid 2 | 2 to 2.8 oz | | Treatment may be warranted when there are 7 or more per square yard. |
| | Dimethoate 4EC | 1 pt | | |
| | *Lorsban 4E | ½ to 1 pt | | |
| | *Mustang Max | 3.2 to 4 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Sevin XLR Plus | ½ to 1½ qt | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Greenbug | Dimethoate 4EC | ½ to 1 pt | Over row | Treat when greenbug damage is sufficient to cause death of more than 2 normal-sized leaves before the hard-dough stage. |
| | *Lorsban 4E | ½ to 2 pt | | |
| Sorghum midge | *Asana XL | 2.9 to 5.8 oz | Over row | Apply during bloom when 50% of heads have begun to bloom and there is 1 or more midge adults (flies) per head. |
| | *Baythroid 2 | 1 to 1.3 oz | | |
| | Dimethoate 4EC | ¼ to ½ pt | | |
| | *Lorsban 4E | ½ pt | | |
| | *Mustang Max | 1.28 to 4 oz | | |
| | *Proaxis | 1.92 to 2.56 oz | | |
| | *Warrior | 1.92 to 2.56 oz | | |

**Table 6. Insecticides for grain sorghum (cont.)**

| Insect | Insecticide[a,b] | Amount of product per acre[a,b] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Webworms | *Baythroid 2 | 1.3 to 2.8 oz | Over row | Treat when 5 or more larvae per head are found. |
| | *Lorsban 4E | 1 pt | | |
| | *Mustang Max | 1.76 to 4 oz | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Tracer 4SC | 1.5 to 3 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | |
| Yellow sugarcane aphid | Dimethoate 4EC | ½ to 1 pt | Over row | Sprays should be applied at first sign of damage to seedling sorghum; 5 to 10 aphids per leaf. |
| | *Lorsban 4E | ½ to 1 pt | | |

*Use restricted to certified applicators.
[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.
[b]Some sorghum varieties are sensitive to organophosphate insecticides.

**Table 7. Insecticides for small grains (barley, oats, rye, wheat)**

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Aphids (English grain aphid, greenbug, oat bird-cherry aphid) | Dimethoate 4EC | ½ to ¾ pt | On foliage | Treat when there are 12 to 15 aphids per tiller during seedling to boot stage. |
| | *Penncap-M | 2 to 3 pt | | |
| | *Proaxis | 2.56 to 3.84 oz | | Use Dimethoate and Warrior on wheat only. Do not use Penncap-M in rye. |
| | *Warrior | 2.56 to 3.84 oz | | |
| Armyworm | *Mustang Max | 1.76 to 4 oz | On foliage | Treat when there are 6 or more non-parasitized armyworms (¾ to 1¼ inches long) per linear foot of row and before extensive head cutting occurs. |
| | *Penncap-M | 2 to 3 pt | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Tracer 4SC | 1 to 3 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | Do not use Penncap-M in rye. Mustang Max and Warrior are labeled for use only in wheat. |
| Cereal leaf beetle | *Mustang Max | 1.76 to 4 oz | On foliage | Treat when the combination of eggs and larvae averages 3 or more per stem. |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | Sevin XLR Plus | 1 qt | | |
| | Tracer 4SC | 1 to 3 oz | | Mustang Max, Sevin XLR Plus, and Warrior are labeled for use only in wheat. |
| | *Warrior | 2.56 to 3.84 oz | | |

**Table 7. Insecticides for small grains (barley, oats, rye, wheat) (cont.)**

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Grasshoppers | Dimethoate 4EC | ¾ pt | On foliage | During fall when damage is apparent, treat field borders and noncrop areas to stop migration. |
| | *Mustang Max | 3.2 to 4 oz | | |
| | *Penncap-M | 2 to 3 pt | | |
| | *Proaxis | 2.56 to 3.84 oz | | |
| | *Warrior | 2.56 to 3.84 oz | | Do not use Penncap-M in rye. Dimethoate, Mustang Max, and Warrior are labeled for use only in wheat. |

*Use restricted to certified applicators.
[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

**Table 8. Insecticides for grass hay or pasture**

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Armyworm | Sevin XLR Plus | 1 qt | On foliage | Do not apply when weeds are blooming. |
| Grasshoppers | Sevin XLR Plus | 1 qt | On foliage | Treat when there are 15 to 20 per square yard. Do not apply when weeds are blooming. |

[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

**Table 9. Insecticides for noncrop areas**

To avoid injury to bees, do not apply sprays to noncrop areas if weeds are blooming.

| Insect | Insecticide[a] | Amount of product per acre[a] | Placement | Timing of application, comments |
|---|---|---|---|---|
| Grasshoppers | *Asana XL | 2.9 to 5.8 oz | On foliage | Treat when grasshopper nymphs average 15 to 20 per square yard along roadsides and fencerows. Apply treatments while hoppers are small and before they migrate into row crops. Do not spray areas adjacent to water or where runoff is likely to occur. Do not spray ditch banks. |
| | Imidan 70W | 2⅛ to 2¾ lb | | |
| | Sevin XLR Plus | 1 qt | | |

*Use restricted to certified applicators.
[a]The formulation of the product most commonly used in Illinois is listed. If you use another formulation, *read the label* to determine the amount of product per acre. Also, read the product label for precautions and restrictions.

# 2

# Weed Control for Corn, Soybeans, and Sorghum

This guide is based on the results of research conducted by the personnel of the University of Illinois Agricultural Experiment Station, other experiment stations, and the U.S. Department of Agriculture (USDA). The soils, crops, and weed problems of Illinois have been given primary consideration.

The user should have an understanding of cultural and mechanical weed control. As these practices change little from year to year, this publication focuses on making practical, economical, and environmentally sound decisions regarding herbicide use.

Most of the suggestions in this guide are intended primarily for ground applications. For aerial applications, such factors as carrier volume and adjuvant selection may differ.

## Precautions

The benefits of chemical weed control must be weighed against the potential risks to crops, people, and the environment. Discriminate use should minimize exposure of humans and livestock, as well as desirable plants. Risks can be reduced by observing current label precautions.

### Current Label

Precautions and directions for use may change. Herbicides classified as restricted use pesticides (RUPs) must be applied by certified applicators (Table 4). Use of these herbicides may be restricted because they are toxic or pose environmental hazards. The degree of toxicity is indicated by the signal word on the label.

### Signal Word

*Heed the accompanying precautions.* The signal words for herbicides discussed in this guide are given in Table 4. "Danger–Poison" and "Danger" indicate high toxicity hazards, whereas "Warning" indicates moderate toxicity. Always use personal protective equipment (PPE) as specified on the herbicide label for handling and application. Keep persons or animals not directly involved in the operation out of the area. Observe reentry intervals (REIs) as specified on the label. "Agricultural Use Requirement" on the label may require posting of the treated area. Use special drift precautions near residential areas.

### Environmental Hazards

Groundwater advisories (Table 4) must be observed, especially on sandy soils with a high water table. The threat of toxicity to fish and wildlife is indicated under "Environmental Hazards" on the herbicide label. Hazards to endangered species may be indicated.

### Proper Herbicide Use

Apply only to approved crops at the proper rate and time. Illegal residues can result from overapplication or improper timing. Observe the recommended harvesting or grazing intervals after treatment.

### Proper Equipment Use

Make sure that spray tanks are clean and free of other pesticide residues. Many herbicide labels provide cleaning suggestions, which are particularly important when spraying different crops with the same sprayer and especially when using postemergence herbicides.

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

Correctly calibrate and adjust the sprayer before adding the herbicide to the tank.

#### Proper Drift Precautions

Spray only on relatively calm days when the wind is light. Make sure the wind is not moving toward areas of human activity, susceptible crops, or ornamental plants. Nearby residential areas and fields of edible horticultural crops deserve special attention. *Use special precautions with 2,4-D, Banvel or Clarity, Celebrity Plus, Command 3ME, Distinct, glyphosate (many trade names), Gramoxone Max, Hornet WDG, Marksman, NorthStar, Shotgun, and Stinger,* as symptoms of injury have occurred far from the application site.

#### Precautions to Protect the Crop

Avoid applying a herbicide to crops under stress or predisposed to injury. Crop sensitivity varies with size of the crop and climatic conditions as well as previous injury from plant diseases, insects, or chemicals.

#### Proper Recropping Interval

Failure to observe the proper recropping intervals may result in carryover injury to the next crop. Soil texture, organic matter, and pH may affect herbicide persistence. Check Tables 5a and 5b and current labels for recropping restrictions.

#### Proper Storage

Promptly return unused herbicides to a safe storage place. Pesticides should be stored in their original, labeled containers in a secure place away from unauthorized people (particularly children) and livestock and their food or feed.

#### Proper Container Disposal

Containers for liquids should be pressure- or triple-rinsed. Properly rinsed containers can be recycled and may be accepted by some sanitary landfills. Haul paper containers to a sanitary landfill or burn them in an approved manner. If possible, use mini-bulk returnable containers.

## Cultural and Mechanical Control

Good cultural practices that aid in weed control include adequate seedbed preparation, adequate fertilization, crop rotation, planting on the proper date, using the optimal row width, and seeding at the rate required for optimal stands.

Planting in relatively warm soil can help the crop emerge quickly and compete better with weeds. Good weed control during the first 3 to 5 weeks is extremely important for both corn and soybeans, as they usually compete quite well with most of the weeds that begin growing later. Narrow rows help the crop compete better with the weeds. However, if herbicides alone cannot give adequate weed control, then keep rows wide enough to allow for cultivation.

If adequate rainfall does not occur after the application of a soil-applied herbicide, use a rotary hoe after weed seeds have germinated but before most weeds have emerged. Operate it at 8 to 12 miles per hour, and weight it enough to stir the soil and kill the tiny weeds. Rotary hoeing also aids crop emergence if the soil is crusted.

Row cultivators also should be used while weeds are small. Throwing soil into the row can help smother small weeds. Proper adjustment of equipment (speed, depth, and angle) is essential for minimizing crop injury and pruning of crop roots. Cultivation may not be needed where herbicides are adequately controlling weeds unless the soil is crusted or needs aeration.

## Herbicide Incorporation

Trifluralin is incorporated to minimize surface loss. Other soil-applied herbicides may be incorporated to minimize dependence on timely rainfall or to improve control of certain weed species.

Incorporation should place the herbicide uniformly throughout the top 1 to 2 inches of soil for the best control of most weeds. Slightly deeper placement may improve the control of certain weeds under relatively dry conditions but may dilute the herbicide and reduce its effectiveness. Incorporation tools usually distribute most of the herbicide into the soil to about one-half the depth of operation. Thus, for most herbicides, the suggested depth of operation is 3 to 4 inches for most tillage tools.

Thorough incorporation often requires two passes, but the second pass may be delayed if the first pass adequately reduces surface loss of the herbicide. The second pass should be at an angle to the first pass and no deeper. Single-pass incorporation may be adequate, especially if rotary hoeing, cultivation, or subsequent herbicide treatment maintains adequate weed control.

Accurate application and uniform distribution help minimize crop injury and carryover problems. Uniform distribution depends on the type of equipment used, the depth and speed of operation, the texture of the soil, and the amount of soil moisture. Field cultivators, tandem disks, and disk–chisels or other combination tools are sometimes used for incorporation. More uniform herbicide distribution is provided by two passes than one, whether with a field cultivator or tandem disk.

### Field Cultivators

Field cultivators used for herbicide incorporation need at least three rows of shanks equipped with sweeps (not points), each with an effective working space of 7 inches or less. Sweeps for C-shank cultivators should be at least as wide as the effective shank spacing. Set the equipment to cut in a level position at 3 to 4 inches deep and to operate at a minimum of 5 miles per hour.

### Tandem Disks

Tandem disks used for herbicide incorporation should have disk-blade diameters of 20 inches or less and blade spacings of 7 to 9 inches. *Do not use larger disks for incorporating herbicides.* Set the disk to cut 3 to 4 inches deep, and operate at 4 to 6 miles per hour or a speed sufficient to move soil the full width of the blade spacing. Slower speeds or lack of a leveling device can result in herbicide streaking.

### Combination Tools

Several tillage tools combine disk gangs, field cultivator shanks, and leveling devices. Many combination tools can handle large amounts of surface residue without clogging and yet leave adequate crop residue on the soil surface for erosion control. Results indicate that these combination tools may provide more uniform one-pass incorporation than a disk or field cultivator, but one pass with them is generally no better than two passes with the disk or field cultivator.

## Chemical Weed Control

Plan your weed-control program to fit your soils, tillage program, crops, weed problems, and farming operations. Good herbicide performance depends on the weather and on wise selection and application. Your decisions about herbicide use should be based on the nature and seriousness of your weed problems. The herbicide susceptibility of common weed species is indicated in several tables in this guide.

Corn and soybean are occasionally injured by herbicides applied to these crops. To minimize crop injury, apply the herbicide uniformly at the stage of crop growth specified on the label and at the correct rate (see the section on "Herbicide Rates"). Crop tolerance ratings for various herbicides are also given in the tables in this chapter. Unfavorable conditions such as cool, wet weather; delayed crop emergence; deep planting; seedling diseases; soil in poor physical condition; and poor-quality seed may contribute to crop stress and herbicide injury. Hybrids and varieties vary also in their tolerance to herbicides and environmental stress factors. Once injured by a herbicide, plants may be more prone to disease.

Crop-planting options for next season also must be considered when selecting a herbicide program. Corn and soybean herbicides may have restrictive recropping intervals for some agronomic and many vegetable crops. Tables 5a and 5b cover recropping intervals for the major agronomic crops grown in Illinois, but always check the label. Recropping intervals may be extended for previous, subsequent, or late-summer herbicide applications as well as droughty weather or soil pH. Command or Scepter (in northern Illinois) can restrict planting wheat after soybean, whereas atrazine restricts planting wheat after corn. For soybean, the persistent corn herbicides of concern are atrazine, clopyralid, and prosulfuron. STS soybeans may help reduce the carryover problem with prosulfuron. Special concerns are rate and date of application, as well as rainfall amount and soil pH. When corn follows soybean, the major concerns are imazaquin and chlorimuron; but some corn hybrids may minimize this concern (see the label). Be sure that the application of persistent herbicides is uniform and properly timed to minimize injury to wheat or corn. Refer to the herbicide label for information about cropping sequence and appropriate recropping intervals.

For some herbicides, different formulations and concentrations are available under the same trade name. *No endorsement of any trade name is implied, nor is discrimination against similar products intended.*

### Weed Resistance to Herbicides

One of the disadvantages of chemical weed control is that weeds can become resistant to herbicides. Herbicide resistance is presently a problem in Illinois. There are triazine-resistant pigweed, waterhemp, lambsquarters, and kochia, as well as acetolactate synthase (ALS)–resistant waterhemp, kochia, cocklebur, ragweed, eastern black nightshade, giant foxtail, and shattercane. There is also diphenylether-resistant (PPO) waterhemp. All of these hebicides have been widely used in Illinois; and, if not managed properly, the problem of herbicide-resistant weeds has the potential to increase.

Certain management strategies can help deter the development of herbicide-resistant weeds:

1. Scout fields regularly to identify resistant weeds. Monitor changes in weed populations to restrict the spread of herbicide-resistant weeds.
2. Rotate herbicides with different sites of action. Do not make more than two consecutive applications of herbicides (whether within the same year or in successive years) with the same site of action against the same weed. Instead, include other effective management strategies for weed control.

This approach is especially critical when using herbicide-tolerant crops.

3. Use multiple sites of action (tank mix, premix, or sequential) that effectively control potentially resistant weeds.
4. Where practical, use rotary hoeing and cultivation to control weed escapes. If necessary, use hand weeding to minimize the spread of herbicide-resistant weeds.
5. Be aware that resistant weeds can spread from total-vegetation-control (TVC) programs used along highway, railroad, or utility rights-of-way areas near your farm.

For further information on the causes of herbicide resistance and strategies to minimize it, visit your local Extension office or see Chapter 14, "Weed Resistance to Herbicides," in the current edition of the *Illinois Agricultural Pest Management Handbook.*

### Herbicide Combinations

Herbicide combinations (tank mixes, premixes, or sequential applications) can control more weed species, reduce carryover, and reduce crop injury. Some labels allow split applications (the same herbicide applied at different times) or sequential applications (different herbicides applied at different times). Numerous combinations of herbicides are sold as premixes, and some are tank-mixed. Registered premixes are shown in Tables 6 and 7 in this chapter. Tank-mixing allows you to adjust the ratio of herbicides to fit local weed and soil conditions, whereas premixes may overcome some of the compatibility problems found with tank-mixing. When using a tank mix, you must follow restrictions for all products used in the combination.

Problems may occur when mixing emulsifiable-concentrate (EC) formulations with suspendible herbicides, such as liquid-flowable (L) or dry-flowable (DF) formulations. Proper mixing procedure may minimize these problems. The label of most soil-applied herbicides specifies a compatibility test when a liquid fertilizer carrier is used. First, fill tanks at least one-fourth full with carrier (water or liquid fertilizer) and start tank agitation. Next, if needed, add the compatibility agent at the rate indicated by the test or adjuvant label. Add suspendible herbicide formulations as just described and completely suspend (thoroughly mix) before adding emulsifiable concentrates. Mix ECs with equal volumes of water (thoroughly emulsify) before adding them to the tank. Add soluble formulations (those that do not emulsify or disperse) last. Empty and clean spray tanks often enough to prevent accumulation of material on the sides and bottom of the tank.

### Herbicide Rates

Herbicide rates vary according to the time and method of application, soil conditions, tillage system used, and seriousness of the weed infestation. Rates of individual components within a combination are usually lower than rates for the same herbicides used alone.

The rates for soil-applied herbicides often vary with the texture of the soil and the amount of organic matter the soil contains. For sandy soils, the herbicide label may specify reducing the rate or not using any if crop tolerance to the herbicide is marginal. Postemergence rates often vary, depending on the size and species of the weeds.

The rates given in this chapter are, unless otherwise specified, broadcast rates for the amount of formulated product. If you plan to band or direct herbicides, adjust the amount per crop acre according to the percentage of the area actually treated. Herbicides may have formulations with different concentrations of the active ingredient. Be sure to read the label and make necessary adjustments when changing formulations.

### Postemergence Herbicide Principles

Postemergence herbicides applied to growing weeds generally have foliar rather than soil activity; however, some may have both. The rates and timing of applications are based on weed size and climatic conditions. When weeds are small, they usually can be controlled with lower application rates. Larger weeds often require higher herbicide rates. Herbicide penetration and action are usually greater with warm temperature and high relative humidity. Rainfall occurring too soon after application (0.5 to 6 hours, depending on the herbicide) can reduce weed control.

Translocated herbicides are most effective at lower spray volumes (5 to 20 gallons per acre), whereas contact herbicides require more complete coverage. Foliar coverage increases as water volume and spray pressure are increased. Spray nozzles that produce small droplets also improve coverage. For contact herbicides, labels usually specify to use 10 to 40 gallons of water per acre for ground application and a minimum of 5 gallons per acre for aerial application. Spray pressures of 30 to 60 psi are often suggested with flat-fan or hollow-cone nozzles to produce small droplets and improve canopy penetration. *These small droplets are subject to drift.*

Crop size limitations may be specified on the label to minimize crop injury and maximize weed control. If weeds are smaller than the crop, basal-directed sprays may minimize crop injury because they place more herbicide on the weeds than on the crop. If the weeds are taller than the crop, rope-wick or sponge-type applicators may be used to place the herbicide

on top of the weeds and minimize contact with the crop. Follow the label directions and precautions for each herbicide.

*Herbicide adjuvants*, such as crop-oil concentrate (COC), nonionic surfactant (NIS), or ammonium fertilizer, may be specified on the herbicide label. Crop-oil concentrates spread the herbicide across the leaf surface, keep the surface moist longer, and aid penetration into the cuticle. COCs are phytobland oils with emulsifier (surfactant) added to allow better mixing with water. The oil may be of petroleum (POC) or vegetable (VOC) origin. Methylated seed oils (MSO) are esters of fatty acids formulated to provide better performance than a conventional VOC. Most labels allow POC, MSO, or VOC. COCs are used at 1 to 3 pints per acre or about 1 percent on a volume basis. Oils generally have a greater postemergence effect than surfactants do *on both weeds and crops.*

Surfactants cause a spreading and wetting action by decreasing the surface tension of water, allowing the spray mix to spread over waxy or hairy leaf surfaces rather than forming droplets. Because more leaf surface is covered, more herbicide may be absorbed. Surfactants may contain fatty acids to improve penetration. Labels may specify that the NIS should contain a minimum of 75 to 85 percent active ingredient or else you should use a higher surfactant rate. An NIS usually is applied at 0.25 to 1 pint per acre or ⅛ to ½ percent on a volume-to-volume basis.

Ammonium fertilizers are added to increase herbicide activity on weed species such as velvetleaf. Ammonium sulfate and urea–ammonium nitrate solution (28-0-0 UAN) are the most common fertilizer adjuvants, although ammonium polyphosphate (10-34-0 APP) may also be specified. UAN usually is used at 2 to 4 quarts per acre. Labels for contact herbicides may specify that a fertilizer adjuvant replace an NIS or a COC, while translocated herbicides usually specify UAN in addition to an NIS or a COC.

Drift-reduction agents are added to the spray tank to reduce small-droplet formation and thus reduce spray-particle drift. See the adjuvant label for rates, as drift retardants vary greatly in formulation.

## Conservation Tillage and Weed Control

Conservation tillage allows crop production, while reducing soil erosion by protecting the soil surface with plant residue. Minimum or reduced tillage refers to any tillage system leaving crop residue on the soil surface, including primary tillage with chisel plows or disks and the use of field cultivators, disks, or combination tools for secondary tillage. Mulch tillage is reduced tillage that leaves at least 30 percent of the soil surface covered with plant residue.

Ridge tillage and zero tillage are conservation tillage systems with no major tillage prior to planting. In ridge tillage, conditions are often ideal for banding preemergence herbicides because cultivation is a part of the system. "No-till" is actually "slot tillage" for planting with no overall primary or secondary tillage. No-till planting conserves moisture, soil, and fuel. It also allows timely planting of soybeans or sorghum after winter wheat harvest (double-cropping).

If tillage before planting is eliminated, undesirable existing vegetation must be controlled with herbicides before, at, or after planting. The elimination or reduction of preplant tillage and row cultivation puts a greater reliance on chemical weed control. Greater emphasis may be placed on preplant or postplant soil-applied herbicides that are not incorporated or on foliar-applied herbicides. Herbicides are available to allow "total postemergence" weed control in corn and soybeans.

Where primary tillage is minimized, soil-residual herbicides applied several weeks before planting may reduce the need for a "knockdown" herbicide. However, early preplant (EPP) application may require additional preemergence or postemergence herbicides or cultivation for satisfactory weed control after planting.

Corn and soybean are the primary crops in Illinois, and they are often planted in sequence. Modern equipment allows successful no-till planting in corn and soybean stubble. The use of a disk or chisel plow on corn stubble may still provide adequate crop residue to meet mulch-till requirements.

Soybean stubble is often ideal for minimum- or zero-tillage production systems. Primary tillage is rarely needed, and the crop residue, if properly spread, should not interfere with herbicide distribution. Early preplant application of preemergence herbicides or the use of postemergence herbicides often provides adequate weed control.

The existing vegetation in corn and soybean stubble is usually annual weeds. If small, weeds often can be controlled before planting with herbicides that have both foliar and soil-residual activity. In cases where annual vegetation is more than 2 to 3 inches tall at planting, either a contact or translocated broad-spectrum herbicide (such as paraquat or glyphosate) can be added to the spray tank. If the problem is broadleaf weeds, 2,4-D or dicamba may be used prior to planting corn or no-till soybeans, *but observe the planting delay specifications.* Herbicides that can be used prior to planting to control existing vegetation are listed in Tables 1, 2, and 3.

Some growers in Illinois are using annual cover crops not only to control weed problems at planting

but also for erosion control. Annual cover crops in Illinois are hairy vetch, winter rye, and winter wheat. Hairy vetch, a winter annual legume, is easily controlled with 2,4-D or dicamba before planting corn. Winter rye or winter wheat can be controlled by glyphosate prior to planting corn or soybeans. Cover crops should be controlled prior to planting crops, but the question is "How early do we do this?" If the season is dry, late control depletes soil moisture for crop establishment; but if the season is wet, late control helps dry out the soil. Decomposing residue of small-grain cover crops can sometimes inhibit corn seedlings.

*Perennial sods* require a different approach. It is estimated that 65 to 70 percent of the Conservation Reserve Program (CRP) acres in the Corn Belt may return to cropland. Many of these acres have been planted to perennial grass or legume sods. The questions here are these: What is the best way to control sod species? What is the best timing for control, and what are the best cropping choices? *Sods should be killed prior to planting crops into them* (Table 10).

*Perennial grass sods* were planted on much of the CRP land. Glyphosate provides the best "sod grass" control. *Fall application is more effective than spring application.* Mowing the sod in late summer allows adequate regrowth for timely fall application. Active regrowth should be 6 to 8 inches before fall application. Springtime applications must be delayed to obtain 6 to 10 inches of new growth for effective control. In the spring, paraquat (Gramoxone Max) + atrazine is often as effective as glyphosate for controlling several grass species (Table 10). Preplant glyphosate rates may be reduced if followed with atrazine at corn planting. If grass–legume mixes are established, the legume component must also be controlled.

*Perennial legume sods* must have 6 to 8 inches of new growth for effective control. *Do not take a spring cutting before controlling legumes,* as this delays corn planting. Corn better utilizes legume nitrogen and allows preplant or postemergence use of 2,4-D or dicamba. Dicamba controls alfalfa better than 2,4-D does, but either controls red clover. When glyphosate is used, adding dicamba improves alfalfa control, and adding 2,4-D improves dandelion control. Glyphosate may be applied before the last alfalfa cutting in the fall or spring. Clover sods may be controlled by atrazine (see Tables 9 and 10).

## Fall Herbicide Applications

The practice of applying herbicides in the fall has been increasing in Illinois. Growers are using two very different approaches to fall herbicide applications. The first approach is to apply soil-applied grass herbicides, such as metolachlor, flufenacet, dimethenamid, or pendimethalin, to control annual grass species the following season. These herbicide applications are generally made north of Interstate 80, in conventional tillage fields, and after soil temperatures decrease to 50°F but before the ground freezes. The reasoning behind these fall herbicide applications is to spread the workload out for the applicators, as well as to ensure adequate precipitation for incorporation of these herbicides. There are disadvantages to these types of applications: first, they require higher herbicide application rates and, second, the grass control may not last throughout the entire growing season due to herbicide dissipation. There are several herbicides that can be used in the fall for annual grass control. These herbicides are identified in Tables 1 and 3 (see the "Application timings" section in these tables).

The second approach to fall herbicide applications is to control winter annual and perennial weeds in no-till corn and soybean fields. This approach is used primarily by growers who have had difficulty controlling winter annual and perennial weeds in no-till fields in the spring. Winter annual weeds, such as purple deadnettle, henbit, chickweed, horseweed (marestail), and a number of mustard species, can form a dense weed mat that can be difficult to control with spring burndown herbicides. These problems can result from insufficient spray coverage, fluctuating spring temperatures, and timeliness of the application due to uncooperative spring weather.

Controlling winter annual and simple perennial weeds in the fall has a number of potential benefits. This practice can prevent dense mats of winter annual weeds that can physically interfere with planting and tillage, reduce vegetation where insects may harbor, and possibly allow earlier planting due to faster soil drying and warming. In addition, controlling these weeds in the fall prevents them from producing seed, thereby decreasing the soil seed bank and helping reduce future problems with these species. Fall control of simple perennials, such as dandelion and white cockle, is much more effective than controlling these weeds in the spring. In the fall, food reserves in these perennials are being moved to the roots. When a systemic herbicide is applied, that herbicide moves with the food reserves to the roots and can cause complete control of the roots. Additionally, higher rates of some translocated herbicides (such as 2,4-D) can be used in the fall, thus allowing for greater control of perennial weeds like dandelion.

There are currently three basic strategies to control winter annual weeds with fall herbicide applications: (1) apply a herbicide with residual soil activity before most of the winter annual weed species germinate; (2) apply a nonresidual herbicide, such as glyphosate,

2,4-D, or paraquat (Gramoxone Max), to emerged winter annual, biennial, and perennial weeds while they are still relatively small or in the rosette stage; and (3) use a combination of strategies 1 and 2. The goal of all of these strategies is to reduce the amount of total vegetation that needs to be dealt with in the spring prior to planting, possibly even eliminating the need for a burndown herbicide application. While these approaches sound good in theory, the actual end results may or may not be as good as expected. Several factors, such as herbicide selection, application rate, weather conditions, and time of planting, ultimately determine how well this system works.

Fall herbicide treatments can be an extremely effective tool in managing winter annual, biennial, and simple perennial weeds. So how do you know if fall herbicide applications are suitable for your farming operation? These applications are most effective on fields where these weeds have been a problem in the past. If spring herbicide treatments have been effectively controlling these species and they do not appear to be increasing, fall herbicide applications may provide little or no benefit in these fields. It is also important to note that, even though winter annual weeds may be controlled by fall applications, under certain conditions a spring burndown treatment may still be needed. Herbicides that can be applied in the fall for winter annual weed control are identified in Tables 1 and 3 (see the "Application timings" section in these tables).

## Recommended Web Resources

**http://www.cdms.net**
This is an excellent index of chemical companies involved in agriculture that is searchable by product (trade name). It contains links to the companies' Web sites and is a good resource for obtaining current product label recommendations.

**http://www.greenbook.net**
This Web site contains extensive information on pesticides, including current pesticide labels and material safety data sheets.

## Tables



Contributions of other weed scientists and staff of the University of Illinois and at other institutions, as well as the input of industry weed scientists, are gratefully acknowledged.

## Authors

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**Table 1. Corn herbicides (Read and follow label directions before using product.)**

| Trade name | Formulation | Rate / A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **2,4-D Amine**<br>(many trade names) | 3.8 lb a.e.<br>(many) | 1 to 2 pt<br><br>2 to 3 pt<br><br><br>0.5 to 1.0 pt<br><br>1 to 1.5 pt | **PP:** Apply from 7 to 14 days before planting.<br>**PRE:** Apply from 3 to 5 days after planting but before corn emerges.<br>**POST:** Apply to corn up to 8 in. tall.<br>**POST-directed:** Apply to corn more than 8 in. tall. | • Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25).<br>• PP and PRE applications are to control existing vegetation prior to corn emergence.<br>• Registered for use on field and sweet corn.<br>• *Do not* apply PP or PRE on light, sandy soils.<br>• *Do not* spray corn from tassel to dough stage.<br>• Corn is brittle 1 to 2 weeks following application and may be susceptible to breakage from wind or cultivation.<br>• Corn hybrids differ in their sensitivity to 2,4-D.<br>• *Do not* forage for feed fodder for 7 days after application.<br>• Spray particles can drift and cause injury to susceptible plants. |
| **2,4-D Ester**<br>(many trade names) | 3.8 lb a.e.<br>(many) | 1 to 2 pt<br><br>2 to 4 pt<br><br><br>0.5 to 0.75 pt<br><br>0.5 to 0.75 pt<br><br>1 to 2 pt | **PP:** Apply from 7 to 14 days before planting.<br>**PRE:** Apply from 3 to 5 days after planting but before corn emerges.<br>**POST:** Apply to corn up to 8 in. tall.<br>**POST-directed:** Apply to corn more than 8 in. tall.<br>**Preharvest:** Apply after dent stage. | • Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25).<br>• Registered for use on field corn.<br>• Use 0.75 pt/A for control of perennial weeds.<br>• 2,4-D ester can volatilize if temperatures exceed 85°F.<br>• *See "Remarks and limitations" for 2,4-D Amine.* |
| **AAtrex, Atrazine**<br>atrazine | 4L<br>90DF | 0.5 to 2.0 lb a.i. | **EPP:** Apply up to 45 days before planting except on coarse-textured soils.<br>**PPI:** Apply up to 14 days before planting.<br>**PRE:** Apply before crop and weeds emerge.<br>**POST:** Apply to corn up to 12 in. tall. | • Controls annual broadleaf and certain grass weeds (Table 14).<br>• Atrazine is a restricted use pesticide (RUP).<br>• *Do not* apply more than 2.5 lb a.i. atrazine/A in a calendar year.<br>• *Do not* apply more than 1.6 lb a.i. atrazine/A/application on highly erodible soils with less than 30% residue cover.<br>• *Do not* apply more than 2.0 lb a.i. atrazine/A/application on soils that are not highly erodible or on highly erodible soils with at least 30% residue cover. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **AAtrex, Atrazine (cont.)** | | | | • Risk of carryover is greater on soils with pH greater than 7.2.<br>• POST applications should include a COC. |
| **Accent**<br>nicosulfuron | 75WDG | 0.33 to 1.33 oz | **POST:** Apply to field corn up to 20 in. tall or through the V6 stage, whichever is more restrictive.<br>**POST-directed:** Apply to field corn from 20 to 36 in. tall or before the V10 stage, whichever is more restrictive. | • Controls grass weed species (Table 12).<br>• Registered for use on field corn, field corn grown for seed, and food grade corn hybrids.<br>• See Table 16 for compatibility with soil insecticides.<br>• Must include a COC or an NIS; the addition of a nitrogen source is required.<br>• *Do not* apply more than 1.33 oz/A of Accent per year.<br>• *Do not* tank-mix with Basagran, Laddok, or 2,4-D.<br>• Accent will not control ALS-resistant weed species. |
| **Accent Gold**<br>51.4% clopyralid +<br>15.9% flumetsulam +<br>5.4% nicosulfuron +<br>5.4% rimsulfuron | 78.1WDG | 3.5 oz | **POST:** Apply to corn up to 12 in. tall or the V6 stage, whichever is more restrictive. | • Controls several grass and broadleaf weed species (Tables 12 and 14).<br>• *Do not* apply to seed corn, popcorn, or sweet corn.<br>• *Do not* apply to fields previously treated with Hornet or Stinger in the same cropping season.<br>• Must include a COC; the addition of a nitrogen source is recommended.<br>• See Table 16 for compatibility with soil insecticides. |
| **Aim**<br>carfentrazone | 1.9EW | 0.5 to 1.0 fl oz | **Preplant Burndown:** Apply from 30 days prior to planting through corn emergence.<br>**POST:** Apply to corn up to the V8 stage.<br>**POST-directed:** Apply to corn from the V8 to V14 stage. | • Controls some annual broadleaf weeds (Table 14).<br>• Registered for use on field corn, seed corn, popcorn, corn silage, and sweet corn.<br>• For broad-spectrum control, Aim will need to be tank-mixed.<br>• Must include an NIS; under dry conditions, a COC can be used.<br>• The use of a COC will increase corn leaf burn and speckling. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate / A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Balance PRO** isoxaflutole | 4SC | 1.5 to 4.5 fl oz | **EPP:** Apply 30 days prior to planting with a planned POST program; otherwise, apply 21 days prior to planting. **PPI:** Apply 30 days prior to planting with a planned POST program; otherwise, apply 21 days prior to planting. **PRE:** Apply prior to crop emergence. | • Controls annual broadleaf and grass weeds (Tables 12 and 14). • Registered for use on field corn. • Balance PRO is a restricted use pesticide (RUP). • *Read* and *observe* all environmental precautions. • Adjust rates according to soil texture and organic matter. • *Do not* apply to emerged corn. • *Do not* apply to very sandy soils. • Corn hybrids vary in their tolerance to Balance PRO. • Balance PRO may be tank-mixed with several herbicides to increase grass control. |
| **Banvel** dicamba | 4L | 0.5 to 1 pt<br>1 pt<br>0.5 to 1 pt<br>0.5 pt<br>0.5 pt | **Preplant Burndown:** Apply to actively growing weeds. **PRE:** Apply prior to crop emergence. **EPOST:** Apply to corn from spike up to 8 in. tall or the 5-leaf stage, whichever is more restrictive. **LPOST:** Apply to corn from 8 to 36 in. tall, or 15 days prior to tassel emergence. **POST-directed:** Apply when corn leaves prevent coverage, when sensitive crops are near-by, or when mixing with 2,4-D. | • Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on field corn, seed corn, popcorn, and silage corn. • *Do not* apply to seed corn or popcorn without verifying with a local seed company. • *Do not* allow contact with corn seed. • *Do not* apply more than 1.5 pt/A of Banvel per year. • Corn may be harvested or grazed for feed once it has reached the milk stage. • *Do not* apply Banvel when soybeans are growing nearby if corn is more than 24 in. tall, soybeans are more than 10 in. tall, or soybeans have begun to bloom. • *Do not* apply in areas where desirable legumes or broadleaf crops are present. • *Do not* apply PRE on coarse-textured soils. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Basagran**<br>bentazon | 4S | 1 to 2 pt | **POST:** Apply to actively growing weeds within the size limits listed on the label. | • Controls broadleaf weeds and sedges (Table 14).<br>• Registered for use on field corn, sweet corn, popcorn, and corn grown for seed or silage.<br>• *Do not* graze treated corn for at least 12 days after application.<br>• *Do not* apply more than 4 pt/A of Basagran per year.<br>• *Do not* apply to corn that is injured or under stress.<br>• Include a COC and/or a spray-grade nitrogen source. |
| **Basis**<br>50% rimsulfuron + 25% thifensulfuron | 75WDG | 0.33 to 0.5 oz<br><br><br><br>0.5 to 1 oz<br><br><br>0.33 to 1 oz<br><br><br>0.33 oz | **Fall Burndown:** Apply after harvest but before the ground freezes.<br>**EPP:** Apply up to 30 days before planting.<br>**PRE:** Apply after planting but before corn emerges.<br>**EPOST:** Apply to corn from spike through the V2 stage. | • Controls certain grass and broadleaf weeds (Tables 12 and 14).<br>• *Do not* apply to popcorn, sweet corn, or field corn grown for seed.<br>• *Do not* apply more than 1 oz/A of Basis in a 12-month period.<br>• If using more than 0.62 oz/A of Basis, *do not* follow with POST applications of Accent Gold, Basis Gold, Steadfast, or Steadfast ATZ.<br>• See Table 16 for compatibility with soil insecticides.<br>• *Do not* tank-mix with Basagran, Laddok, Beacon, or other ALS-inhibiting herbicides (unless on label).<br>• Applications must include a COC or an NIS with an ammonium fertilizer.<br>• Basis will not control ALS-resistant weed species. |
| **Basis Gold**<br>1.34% nicosulfuron + 1.34% rimsulfuron + 86.78% atrazine | 89.5WDG | 14 oz | **POST:** Apply to corn up to 12 in. tall or through the V6 stage, whichever is more restrictive. | • Controls annual grass and broadleaf weeds (Tables 12 and 14).<br>• Basis Gold is a restricted use pesticide (RUP).<br>• *Do not* apply to popcorn, sweet corn, or field corn grown for seed.<br>• See Table 16 for compatibility with soil insecticides.<br>• *Do not* tank-mix with Basagran, Laddok, Beacon, or 2,4-D.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Applications must include a COC or an NIS with an ammonium fertilizer. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate / A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Beacon**<br>primisulfuron | 75WDG | 0.76 oz | **POST:** Apply to corn from 4 to 20 in. tall.<br>**POST-directed:** Drop nozzles may be used on corn from 20 in. tall until tassel emergence. | • Controls annual broadleaf and certain grass weeds (Tables 12 and 14).<br>• *Do not* apply to sweet corn or ornamental corn.<br>• See Table 16 for compatibility with soil insecticides.<br>• *Do not* graze or feed forage from treated areas within 30 days following application.<br>• *Do not* harvest for silage within 45 days after application.<br>• *Do not* harvest for grain within 60 days after application.<br>• Apply with a COC or an NIS.<br>• Beacon will not control ALS-resistant weed species. |
| **Bicep II Magnum**<br>2.4 lb *S*-metolachlor + 3.1 lb atrazine | 5.5L | 1.3 to 2.6 qt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 14 days before planting.<br>**PRE:** Apply to the surface at planting, before crop and weeds emerge.<br>**EPOST:** Apply to corn up to 5 in. tall.<br>**POST-directed:** Apply POST to corn up to 12 in. tall. | • Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14).<br>• Bicep II Magnum is a restricted use pesticide (RUP).<br>• Registered for use on all types of corn.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• This product contains *S*-metolachlor; follow the use limitations listed under Dual II Magnum.<br>• *Do not* graze or feed forage from treated areas within 60 days after application.<br>• Adjust rates according to soil texture, organic matter, and application timing. |
| **Bicep Lite II Magnum**<br>3.33 lb *S*-metolachlor + 2.67 lb atrazine | 6L | 0.9 to 2.2 qt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 14 days before planting.<br>*(continues)* | • Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14).<br>• Bicep Lite II Magnum is a restricted use pesticide (RUP).<br>• Bicep Lite II Magnum contains less atrazine than Bicep II Magnum. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Bicep Lite II Magnum (cont.)** | | | **PRE:** Apply to the surface at planting, before crop and weeds emerge. **EPOST:** Apply to corn up to 5 in. tall. **POST-directed:** Apply POST to corn up to 12 in. tall. | • *See "Remarks and limitations" for Bicep II Magnum.* |
| **Buctril** bromoxynil | 2EC | 1 to 1.5 pt<br><br>1 to 2 pt | **PRE:** Apply from before planting until just prior to corn emergence to control existing vegetation. **POST:** Apply after corn emergence but before tassel emergence. | • Controls certain annual broadleaf weeds (Table 14).<br>• Registered for use on field corn and popcorn.<br>• *Do not* harvest for feed or fodder and *do not* graze within 45 days after application.<br>• *Do not* exceed 2 pt/A of Buctril per season.<br>• *Do not* apply to corn before the 4-leaf stage if using rates greater than 1 pt/A.<br>• Use of an adjuvant or liquid fertilizer may cause excessive leaf burn. |
| **Buctril + atrazine** 1.0 lb bromoxynil + 2.0 lb atrazine | 3L | 1.5 to 3 pt<br><br>1.5 to 3 pt | **PRE:** Apply from before planting until just prior to corn emergence to control existing vegetation. **POST:** Apply after corn emergence but before corn is 12 in. tall. | • Controls certain annual broadleaf weeds (Table 14).<br>• Buctril + atrazine is a restricted use pesticide (RUP).<br>• Registered for use on field corn and popcorn.<br>• *Do not* harvest for feed or fodder and do not graze within 45 days after application.<br>• *Do not* exceed 4 pt/A of Buctril + atrazine per season.<br>• *Do not* apply to corn before the 4-leaf stage if using rates greater than 2 pt/A.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Use of an adjuvant or liquid fertilizer may cause excessive leaf burn. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate / A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Bullet**<br>2.5 lb alachlor +<br>1.5 lb atrazine | 4ME | 2.5 to 4.5 qt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 7 days before planting.<br>**PRE:** Apply after planting but before crop and weeds emerge.<br>**EPOST:** Apply to corn up to 5 in. tall. | • Controls annual grass and broadleaf weeds (Tables 12 and 14).<br>• Bullet is a restricted use pesticide (RUP).<br>• Registered for use on all types of corn.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• *Do not* make more than two applications of Bullet per year or exceed 6.4 qt/A of Bullet per year.<br>• *Do not* harvest for feed or fodder and *do not* graze within 60 days after application.<br>• Adjust rates according to soil texture and organic matter. |
| **Callisto**<br>mesotrione | 4SC | 6 to 7.7 fl oz<br><br>3 fl oz | **PRE:** Apply before crop and weeds emerge.<br>**POST:** Apply to corn up to 30 in. tall or the 8-leaf stage, whichever is more restrictive. | • PRE and POST control of annual broadleaf weeds (Table 14), and POST control of large crabgrass, less than 2 in. tall (Table 12).<br>• Registered for use on field corn, production seed corn, silage corn, yellow popcorn, and sweet corn.<br>• Tank-mixing atrazine with Callisto may improve weed control.<br>• POST applications must include a COC and a spray-grade nitrogen source.<br>• *Do not* apply more than 7.7 fl oz/A of Callisto per season.<br>• *Do not* apply POST to ground treated with Lexar, Lumax, or Camix in the same season.<br>• *Do not* apply POST tank-mixed with emulsifiable-concentrate grass herbicides.<br>• Severe corn injury may result if an organophosphate or carbamate insecticide is applied within 7 days before or 7 days after a Callisto application. |
| **Celebrity Plus**<br>10.6% nicosulfuron +<br>17% diflufenzopyr<br>+ 42.4% dicamba | 70DF | 4.7 oz | **POST:** Apply to corn from 4 to 20 in. tall or the V6 stage, whichever is more restrictive.<br>*(continues)* | • Controls grass and broadleaf weeds (Tables 12, 14, and 25).<br>• Registered for use on field corn.<br>• *Do not* make more than two applications of Celebrity Plus per year or apply more than 9.4 oz/A of Celebrity Plus per year. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Celebrity Plus (cont.)** | | | **POST-directed:** Drop nozzles may be used on corn from 20 to 24 in. tall. | • *Do not* make sequential applications of Banvel, Clarity, Distinct, or Marksman herbicide within 15 days of an application of Celebrity Plus.<br>• *Do not* exceed 0.67 oz/A of nicosulfuron per application or 1 oz/A per season.<br>• *Do not* exceed 0.5 lb a.i./A of dicamba per application or 0.75 lb a.i./A per season.<br>• *Do not* apply within 32 days of forage harvest or 72 days of corn grain or stover harvest.<br>• *Do not* apply in areas where desirable legumes or broadleaf crops are present.<br>• Apply with an NIS and an ammonium nitrogen fertilizer. |
| **Cinch**<br>*S*-metolachlor | 7.64EC | 1 to 2 pt | See Dual II Magnum application timings. | • Cinch contains the same active ingredient as Dual II Magnum; *see "Remarks and limitations" for Dual II Magnum.*<br>• *Will not control emerged weeds.* |
| **Cinch ATZ**<br>2.4 lb *S*-metolachlor + 3.1 lb atrazine | 5.5L | 1.3 to 2.6 qt | See Bicep II Magnum application timings. | • Cinch ATZ contains the same active ingredients as Bicep II Magnum; *see "Remarks and limitations" for Bicep II Magnum.* |
| **Cinch ATZ Lite**<br>3.33 lb *S*-metolachlor + 2.67 lb atrazine | 6L | 0.9 to 2.2 qt | See Bicep Lite II Magnum application timings. | • Cinch ATZ Lite contains the same active ingredients as Bicep Lite II Magnum; *see "Remarks and limitations" for Bicep Lite II Magnum.* |
| **Clarity**<br>dicamba | 4L | 0.5 to 1 pt<br><br>1 pt<br><br>0.5 to 1 pt | **Preplant Burn-down:** Apply to actively growing weeds.<br>**PRE:** Apply prior to crop emergence.<br>**EPOST:** Apply to corn from emergence up to 8 in. tall or the 5-leaf stage, whichever is more restrictive. *(continues)* | • Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25).<br>• Registered for use on field corn, seed corn, popcorn, and silage corn.<br>• *Do not* apply to seed corn or popcorn without verifying tolerance with a local seed company.<br>• *Do not* allow contact with corn seed. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate / A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Clarity (cont.)** | | 0.5 pt | **LPOST:** Apply to corn from 8 to 36 in. tall, or 15 days prior to tassel emergence. **POST-directed:** Apply when corn leaves prevent coverage, when sensitive crops are nearby, or when mixing with 2,4-D. | • *Do not* apply PRE on coarse-textured soils.<br>• *Do not* make more than two applications of Clarity in a growing season.<br>• Corn may be harvested or grazed for feed once it has reached the milk stage.<br>• Avoid using COCs after crop emergence. Use COCs only in dry conditions or when corn is less than 5 in. tall.<br>• *Do not* apply Clarity when soybeans are growing nearby if corn is more than 24 in. tall, soybeans are more than 10 in. tall, or soybeans have begun to bloom.<br>• *Do not* apply in areas where desirable legumes or broadleaf crops are present. |
| **Define** flufenacet | 4SC | 15 to 25 fl oz | **Fall:** Apply north of Illinois Route 136 after Ocober 15. **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply after planting but be-fore crop and weeds emerge. **POST:** Apply from emergence through the fifth leaf collar. | • Controls annual grass weeds (Table 12).<br>• *Do not* use on popcorn or sweet corn.<br>• *Do not* apply more than 25 oz/A of Define per season.<br>• Plant corn at least 1 to 1.5 in. deep.<br>• Adjust rates according to soil texture, organic matter, and application timing.<br>• *Do not* harvest corn forage within 75 days after a POST application.<br>• *Will not control emerged weeds.* |
| **Degree** acetochlor | 3.8CS | 2.25 to 5.5 pt | **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation. **POST:** Apply to corn up to 11 in. tall. | • Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12).<br>• Degree is a restricted use pesticide (RUP).<br>• Registered for use on field corn, production seed corn, silage corn, and popcorn.<br>• *Read* and *observe* all environmental precautions.<br>• Adjust rates according to soil texture, organic matter, and application timing.<br>• *Will not control emerged weeds.* |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Degree Xtra**<br>2.7 lb acetochlor +<br>1.34 lb atrazine | 4.04CS | 2.9 to 4.3 qt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 14 days before planting.<br>**PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation.<br>**POST:** Apply to corn up to 11 in. tall. | • Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14).<br>• Degree Xtra is a restricted use pesticide (RUP).<br>• Registered for use on field corn, production seed corn, silage corn, and popcorn.<br>• *Read* and *observe* all environmental precautions.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Adjust rates according to soil texture, organic matter, and application timing.<br>• *Do not* graze or feed forage from treated areas within 60 days after application. |
| **Distinct**<br>20% diflufenzopyr +<br>50% dicamba | 70WDG | 6 oz<br><br>4 oz<br><br>4 oz | **EPOST:** Apply to corn from 4 to 10 in. tall.<br>**POST:** Apply to corn from 10 to 24 in. tall.<br>**POST-directed:** Apply to corn 24 to 36 in. tall. | • Controls annual and perennial broadleaf weeds (Tables 14 and 25).<br>• Registered for use on field corn, silage corn, and popcorn.<br>• Distinct should be used sequentially or tank-mixed with a grass herbicide for a complete weed-control program.<br>• POST applications must include an NIS and a spray-grade nitrogen source.<br>• *Do not* apply more than 10 oz/A of Distinct per year.<br>• Allow a minimum of 15 days between sequential applications of Distinct.<br>• *Do not* plant any crops except corn within 30 days after application; corn can be replanted 7 or more days after application.<br>• *Do not* use a COC/MSO with Distinct unless specified for certain tank mixes. |
| **Dual II Magnum**<br>*S*-metolachlor | 7.64EC | 1 to 2 pt | **Fall:** Apply north of Illinois Route 136 after October 31.<br>**EPP:** Apply up to 45 days before planting.<br>*(continues)* | • Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12).<br>• Registered for use on all types of corn. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Dual II Magnum (cont.)** | | | **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** May be applied to corn up to 40 in. tall. | • *Do not* apply more than 3.9 pt/A of Dual II Magnum per season. • *Do not* graze or feed treated forage for 30 days after application. • Adjust rates according to soil texture, organic matter, and application timing. • *Will not control emerged weeds.* |
| **Equip** 30% foramsulfuron + 2% iodosulfuron | 32WDG | 1.5 oz | **POST:** Apply when corn is in the V1 through V4 stage. **POST-directed:** Use drop nozzles when corn is greater than V4 and less than V8. | • Controls grasses and certain broadleaf weed species (Tables 12 and 14). • Registered for use on field corn; not recommended for use on corn grown for seed. • See Table 16 for compatability with soil insecticides. • Certain hybrids are sensitive to Equip. • *Do not* apply to corn exhibiting injury from previous herbicide applications. • *Do not* make more than one application or exceed 1.5 oz/A of Equip per season. • Must include an MSO or ESO in combination with a nitrogen fertilizer. • *Do not* apply within 70 days of harvesting corn grain or 45 days of harvesting corn forage. • *Do not* graze within 45 days of application. • Equip will not control ALS-resistant weed species. |
| **Expert** 1.74 lb *S*-metolachlor + 2.14 lb atrazine + 0.74 lb a.e. glyphosate | 4.88SC | 2.5 to 3.75 qt | **EPP:** Apply up to 30 days before planting. **PRE:** Apply before crop emergence. **POST:** Apply only to glyphosate-resistant hybrids up to 12 in. tall. | • Controls annual and perennial grasses and broadleaves. • Registered for use in field corn, popcorn, and sweet corn. • *Do not* graze or feed forage from treated areas for 60 days following application. • This product contains atrazine; follow the use limitations listed under atrazine. • Expert is a restricted use pesticide (RUP). |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **FieldMaster**<br>2.0 lb acetochlor +<br>1.5 lb atrazine +<br>0.56 lb a.e. glyphosate | 4.06L | 3.5 to 5 qt | **PRE:** Apply before crop emergence.<br>**POST:** Apply only to glyphosate-resistant hybrids up to 11 in. tall. | • Controls sedges, annual grasses, broadleaf weeds, and existing vegetation (Tables 9, 12, and 14).<br>• Registered for use in field corn, production seed corn, silage corn, and popcorn.<br>• FieldMaster is a restricted use pesticide (RUP).<br>• *Read* and *observe* all environmental precautions.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• *Do not* feed forage or graze treated areas within 60 days after application. |
| **FulTime**<br>2.4 lb acetochlor +<br>1.6 lb atrazine<br>**Fultime (cont.)** | 4CS | 2.5 to 5 qt | **EPP:** Apply up to 40 days before planting; use only on medium- and fine-textured soils.<br>**PPI:** Apply up to 14 days before planting.<br>**PRE:** Apply after planting, before crop and weeds emerge.<br>**POST:** Apply to corn up to 11 in. tall. | • Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14).<br>• FulTime is a restricted use pesticide (RUP).<br>• Registered for use on field corn, production seed corn, silage corn, and popcorn.<br>• *Read* and *observe* all environmental precautions.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Adjust rates according to soil texture, organic matter, and application timing. |
| **glyphosate**<br>(many trade names)<br>(See Table 8.) | Various formulations | See Table 8 for product rates. | **EPP Burndown:** Apply before planting to control existing vegetation.<br>**PRE Burndown:** Apply after planting but before corn emerges to control existing vegetation.<br>**POST:** Apply to ***glyphosate-resistant*** corn from emergence through the V8 stage or until corn reaches 30 in. tall, whichever is more restrictive.<br>*(continues)* | • **POST applications:** *Use only on* ***glyphosate-resistant*** *corn hybrids.*<br>• Controls grass and broadleaf weed species (Tables 9, 10, 12, 14, and 25).<br>• Application rates vary with weed size, application timing, and formulation.<br>• Table 8 contains a list of glyphosate formulations.<br>• Check labels for individual product restrictions.<br>• POST-directed applications in glyphosate-resistant hybrids: labeled only for certain hybrids. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **glyhosate (cont.)** | | | **POST-directed:** Apply to glyphosate-resistant corn from 30 to 48 in. tall. | |
| **Gramoxone Inteon** paraquat | 2S | 2.0 to 4.0 pt | **EPP Burndown:** Apply before planting to control existing vegetation. **PRE Burndown:** Apply after planting but before corn emergence to control existing vegetation. **POST-directed:** Apply when corn is at least 10 in. tall. **Preharvest:** Apply at least 7 days prior to harvest. | • Controls existing vegetation (Tables 9 and 10). • Gramoxone Inteon is a restricted use pesticide (RUP). • *Do not* apply broadcast after crop emergence. • *Do not* use around gardens, schools, recreational parks, or playgrounds. • Always add an NIS or a COC to the spray mixture. • Adjust rates according to weed sizes. • *Preharvest:* Apply after black layer has formed at the base of the corn kernels and at least 7 days prior to harvest. • Use an NIS with preharvest applications. |
| **Gramoxone Max** paraquat | 3S | 1.3 to 2.7 pt<br>0.8 to 1.3 pt | **EPP Burndown:** Apply before planting to control existing vegetation. **PRE Burndown:** Apply after planting but before corn emergence to control existing vegetation. **Preharvest:** Apply at least 7 days prior to harvest. | • Controls existing vegetation (Tables 9 and 10). • Gramoxone Max is a restricted use pesticide (RUP). • *Do not* exceed 4 pt/A of Gramoxone Max per season. • *Do not* apply broadcast after crop emergence. • *Do not* use around gardens, schools, recreational parks, or playgrounds. • Always add an NIS or a COC to the spray mixture. • Adjust rates according to weed sizes. • *Preharvest:* Apply after black layer has formed at the base of the corn kernels and at least 7 days prior to harvest. |
| **Guardsman Max** 1.7 lb dimethenamid-P + 3.3 lb atrazine | 5L | 2.5 to 4.6 pt | **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 2 weeks before planting. *(continues)* | • Controls annual grass and broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, seed corn, sweet corn, and popcorn. • Guardsman Max is a restricted use pesticide (RUP). |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Guardsman Max (cont.)** | | | **PRE:** Apply before crop and weeds emerge.<br>**POST:** Apply to corn up to 12 in. tall. | • Split applications of Guardsman Max are recommended if applied more than 30 days EPP.<br>• An NIS or a COC may be used with POST-applied Guardsman Max.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• *Do not* graze or feed field corn forage within 60 days after application.<br>• Adjust rates according to soil texture, organic matter, and cation-exchange capacity. |
| **G-Max Lite**<br>2.25 lb dimethenamid-P +<br>2.75 lb atrazine | 5L | 2.0 to 3.5 pt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 2 weeks before planting.<br>**PRE:** Apply before crop and weeds emerge.<br>**POST:** Apply to corn up to 12 in. tall. | • Controls annual grass and broadleaf weeds (Tables 12 and 14).<br>• Registered for use on field corn, seed corn, sweet corn, and popcorn.<br>• G-Max Lite is a restricted use pesticide (RUP).<br>• G-Max Lite contains less atrazine than Guardsman Max.<br>• *See "Remarks and limitations" for Guardsman Max.* |
| **Harmony GT XP**<br>thifensulfuron | 75DF | 0.083 oz | **POST:** Apply to corn up to 12 in. tall or through the V5 stage, whichever is more restrictive. | • Controls some annual broadleaf weeds.<br>• *Do not* apply to fields treated with Counter insecticide.<br>• Applications must include an NIS or a COC in addition to an ammonium nitrogen fertilizer. |
| **Harness**<br>acetochlor | 7EC | 1.25 to 2.75 pt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 14 days before planting.<br>**PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation.<br>**POST:** Apply to corn up to 11 in. tall. | • Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12).<br>• Harness is a restricted use pesticide (RUP).<br>• Registered for use on field corn, production seed corn, silage corn, and popcorn.<br>• *Read* and *observe* all environmental precautions.<br>• Adjust rates according to soil texture and organic matter.<br>• *Will not control emerged weeds.* |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Harness Xtra 5.6L**<br>3.1 lb acetochlor<br>+ 2.5 lb atrazine | 5.6L | 1.4 to 3 qt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 14 days before planting.<br>**PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation.<br>**POST:** Apply to corn up to 11 in. tall. | • Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14).<br>• Harness Xtra 5.6L is a restricted use pesticide (RUP).<br>• Registered for use on field corn, production seed corn, silage corn, and popcorn.<br>• *Read* and *observe* all environmental precautions.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Adjust rates according to soil texture and organic matter.<br>• *Do not* feed forage or graze treated areas within 60 days after application. |
| **Harness Xtra**<br>4.3 lb acetochlor +<br>1.7 lb atrazine | 6L | 1.8 to 2.3 qt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 14 days before planting.<br>**PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation.<br>**POST:** Apply to corn up to 11 in. tall. | • Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14).<br>• Harness Xtra is a restricted use pesticide (RUP).<br>• Registered for use on field corn, production seed corn, silage corn, and popcorn.<br>• *Read* and *observe* all environmental precautions.<br>• Harness Xtra 6L contains less atrazine than Harness Xtra 5.6L.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Adjust rates according to soil texture and organic matter.<br>• *Do not* feed forage or graze treated areas within 60 days after application. |
| **Hornet WDG**<br>18.5% flumetsulam +<br>50% a.e. clopyralid | 68.5WDG | 4 to 5 oz<br>4 to 5 oz<br>4 to 5 oz<br>4 to 5 oz | **EPP:** Apply up to 30 days before planting.<br>**PPI:** Apply up to 30 days before planting.<br>**PRE:** Apply at or just after planting but before crop and weeds emerge.<br>**SPIKE:** Apply to corn from emergence until 2 in. tall and before the first leaf is unfurled. | • Controls broadleaf weeds (Table 14).<br>• Registered for use on field corn.<br>• **Soil applications:** Corn should be planted at least 1.5 in. deep.<br>• **Soil applications:** *Do not* apply to areas with soil pH greater than 7.8.<br>• **Soil applications:** *Do not* apply to peat or muck soils or to soil with more than 5% organic matter and pH below 5.9. |

*(continues)*

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Hornet WDG (cont.)** | | 2 to 5 oz | **POST:** Apply to corn from spike until 20 in. tall or the V6 stage, whichever is more restrictive. **POST-directed:** Apply to corn up to 36 in. tall. | • **Soil applications:** Use of Hornet on soils with less than 1.5% organic matter may result in unacceptable injury. • **Soil applications:** See Table 16 for compatibility with soil insecticides. • *Do not* exceed 6 oz/A of Hornet WDG per season. • *Do not* harvest field corn within 85 days after application. • Adjust application rates according to soil texture and organic matter (soil-applied) and weed size (POST). • **POST applications:** All applications must include an NIS or a COC; under dry conditions, add an ammonium nitrogen fertilizer. • **POST applications:** *Do not* tank-mix with Laddok or Lightning due to risk of crop injury. |
| **Keystone** 3.0 lb acetochlor + 2.25 lb atrazine | 5.25L | 2.2 to 3.4 qt | **EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to corn up to 11 in. tall. | • Controls annual grasses and broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, production seed corn, silage corn, and popcorn. • Keystone is a restricted use pesticide (RUP). • Keystone may be tank-mixed with a number of herbicides to improve control of certain weed species. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* apply POST using nitrogen as a carrier. • *Do not* feed forage or graze treated areas within 60 days after application. |
| **Keystone LA** 4.0 lb acetochlor + 1.5 lb atrazine | 5.5 L | 1.6 to 3 qt | **EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to corn up to 11 in. tall. | • Controls annual grasses and broadleaf weeds (Tables 12 and 14). • Registered for use on field corn, production seed corn, silage corn, and popcorn. • Keystone LA is a restricted use product (RUP). • Keystone LA contains less atrazine than Keystone. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Keystone LA (cont.)** | | | | • This product contains atrazine; follow the use limitations listed under atrazine.<br>• *Do not* feed forage or graze treated areas within 60 days after application. |
| **Laddok S-12**<br>2.5 lb bentazon +<br>2.5 lb atrazine | 5L | 1.33 to 2.33 pt | **POST:** Apply to corn up to 12 in. tall. | • Controls broadleaf weeds and sedges (Table 14).<br>• Registered for use on field corn, production seed corn, silage corn, sweet corn, and popcorn.<br>• Laddok is a restricted use pesticide (RUP).<br>• *Do not* make more than one application of Laddok per season.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• An adjuvant is required for consistent weed control. |
| **Lexar**<br>1.74 lb S-metolachlor + 0.224 lb mesotrione +<br>1.74 lb atrazine | 3.7L | 3 to 3.5 qt | **EPP:** Apply up to 14 days before planting.<br>**PRE:** Apply before crop and weeds emerge.<br>**POST:** Apply to corn up to 12 in. tall. | • Controls annual grasses and broadleaves.<br>• Registered for use on field corn, production seed corn, silage corn, and yellow popcorn.<br>• Lexar is a restricted use pesticide (RUP).<br>• *Do not* harvest forage, grain, or stover within 60 days after the last application.<br>• *Do not* apply other mesotrione-containing products to ground that has been treated with Lexar in the same season.<br>• *Do not* make a POST application of an organophosphate or carbamate insecticide within 7 days before or after applying Lexar.<br>• This product contains atrazine; follow the use limitations listed under atrazine. |
| **Liberty**<br>glufosinate | 1.67S | 28 to 34 fl oz | **POST:** Apply to corn up to 24 in. tall or the V7 stage, whichever is more restrictive.<br>**POST-directed:** Apply to corn from 24 to 36 in. tall. | • *Use only on* ***Liberty Link*** *hybrids.*<br>• Controls annual grass and broadleaf weed species (Tables 12 and 14).<br>• *Do not* make more than two applications per growing season, or exceed 62 oz/A of Liberty per growing season. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Liberty (cont.)** | | | | • *Do not* harvest for forage within 60 days of application.<br>• *Do not* harvest for grain or fodder within 70 days of application.<br>• *Do not* add any surfactants or crop oils.<br>• Applications must include AMS fertilizer. |
| **Liberty ATZ**<br>1.0 lb glufosinate +<br>3.3 lb atrazine | 4.3L | 40 to 48 fl oz | **POST:** Apply before corn is more than 12 in. tall. | • *Use only on* ***Liberty Link*** *hybrids.*<br>• Controls annual grass and broadleaf weed species (Tables 12 and 14).<br>• Liberty ATZ is a restricted use pesticide (RUP).<br>• *Do not* make more than one application per corn crop.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• *Do not* harvest for forage within 60 days of application.<br>• *Do not* harvest for grain or fodder within 70 days of application.<br>• *Do not* add any surfactants or crop oils.<br>• Applications must include AMS fertilizer. |
| **Lightning**<br>52.5% imazethapyr<br>+ 17.5% imazapyr | 70DG | 1.28 oz | **POST:** Apply to corn up to 20 in. tall or the V6 stage, whichever is more restrictive.<br>**POST-directed:** Apply to corn from 20 in. tall to 45 days prior to harvest. | • *Use only on* ***Clearfield*** *hybrids.*<br>• Controls grass and broadleaf weed species (Tables 12 and 14).<br>• *Do not* make more than one application per growing season.<br>• *Do not* harvest for grain, forage, fodder, or silage within 45 days after application; *do not* graze within 45 days after application.<br>• See Table 16 for compatibility with soil insecticides.<br>• An NIS or COC in combination with a nitrogen-based fertilizer must be included.<br>• Lightning will not control ALS-resistant weed species. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Lumax**<br>2.68 lb *S*-metolachlor<br>+ 0.268 lb mesotrione<br>+ 1.0 lb atrazine | 3.95L | 2.5 to 3.0 qt | **EPP:** Apply up to 14 days before planting.<br>**PRE:** Apply before crop and weeds emerge.<br>**EPOST:** Apply before corn is more than 12 in. tall. | • Controls annual grass and broadleaf weeds (Tables 12 and 14).<br>• Registered for use on field corn, production seed corn, silage corn, and yellow popcorn.<br>• Lumax is a restricted use pesticide (RUP).<br>• Additional atrazine may be added to improve control of certain broadleaf weed species.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• *Do not* apply more than 3 qt/A of Lumax per season.<br>• An NIS may be used with POST-applied Lumax.<br>• *Do not* harvest forage, grain, or stover within 45 days after application; *do not* graze or feed forage from treated areas within 60 days after application.<br>• *Do not* apply other mesotrione-containing products to ground that has been treated with Lumax in the same season.<br>• *Do not* apply POST tank-mixed with organophosphate or carbamate insecticides.<br>• *Do not* apply POST using nitrogen as a carrier. |
| **Marksman**<br>1.1 lb dicamba +<br>2.1 lb atrazine | 3.2L | 2 to 3.5 pt | **PRE:** May be applied after planting and prior to corn emergence.<br>**EPOST:** Apply to corn between emergence and the 5-leaf stage or until corn is 8 in. tall, whichever is more restrictive. | • Controls broadleaf weeds (Table 14).<br>• Marksman is a restricted use pesticide (RUP).<br>• Registered for use on field corn, production seed corn, silage corn, and popcorn.<br>• *Do not* harvest treated plants or graze for feed before the ensilage (milk) stage.<br>• *Do not* make more than two applications per season or exceed 5.25 pt/A of Marksman per season.<br>•*Do not* apply PRE to coarse-textured soils or to any soils with less than 2.5% organic matter.<br>• This product contains atrazine; follow the use limitations listed under atrazine. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Marksman (cont.)** | | | | • This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops.<br>• Adjust rates according to soil texture and organic matter. |
| **Micro-Tech**<br>alachlor | 4CS | 2 to 3.5 qt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 7 days before planting.<br>**PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation.<br>**POST:** Apply before orn is more than 5 in. tall. | • Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12).<br>• Micro-Tech is a restricted use pesticide (RUP).<br>• Registered for use on all types of corn.<br>• *Read* and *observe* all environmental precautions.<br>• *Do not* exceed a total of 4 qt/A of Micro-Tech per year.<br>• Adjust rates according to soil texture and organic matter.<br>• *Will not control emerged weeds.* |
| **NorthStar**<br>7.5% primisulfuron + 39.9% dicamba | 47.4WDG | 5 oz | **POST:** Apply to corn from 4 to 20 in. tall (from the V2 to V6 stage).<br>**POST-directed:** Apply to corn from 20 to 36 in. tall. | • Controls annual broadleaf and certain grass weeds (Tables 12 and 14).<br>• Registered for use on field corn, seed corn, popcorn, and silage corn.<br>• *Do not* apply to corn less than 4 in. tall.<br>• See Table 16 for compatibility with soil insecticides.<br>• *Do not* graze or feed forage from treated areas within 30 days after application.<br>• *Do not* harvest for silage within 45 days after application.<br>• *Do not* harvest for grain within 60 days after application.<br>•*Do not* exceed one application or 5 oz/A of NorthStar per season.<br>• All applications of NorthStar should be made no later than 15 days before tassel emergence.<br>• This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops.<br>• Apply with a COC or an NIS and a nitrogen source. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Option**<br>foramsulfuron | 35WDG | 1.5 to 1.75 oz | **POST:** Apply when corn is in the V1 through V6 growth stage.<br>**POST-directed:** Apply to corn greater than V6 and less than V8. | • Controls grasses and certain broadleaf weed species (Tables 12 and 14).<br>• Registered for use on field corn. Consult seed company before applying on corn grown for seed.<br>• See Table 16 for compatibility with soil insecticides.<br>• Certain hybrids are sensitive to Option.<br>• *Do not* apply to corn that already exhibits herbicide injury from a previous herbicide application.<br>• *Do not* apply within 70 days of harvesting corn grain or 45 days of harvesting corn forage.<br>• *Do not* graze within 45 days of application.<br>• *Do not* exceed two applications or 3.5 oz/A of Option per season.<br>• Must include an MSO or ESO in combination with a nitrogen fertilizer.<br>• Option will not control ALS-resistant weed species. |
| **Outlook**<br>dimethenamid-P | 6EC | 8 to 21 fl oz | **Fall:** Apply north of Illinois Route 136 after October 1.<br>**EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 2 weeks before planting.<br>**PRE:** Apply before crop and weeds emerge.<br>**POST:** May be applied to corn up to 12 in. tall.<br>**Layby:** Apply to corn from 12 to 36 in. tall. | • Controls annual grass and certain small-seeded broadleaf weeds (Table 12).<br>• Registered for use on field corn, popcorn, seed corn, and sweet corn.<br>• *Do not* apply more than 21 fl oz/A of Outlook per season.<br>• *Do not* graze or feed forage from treated areas within 40 days after application.<br>• Adjust rates according to soil texture, organic matter, and cation-exchange capacity.<br>• *Will not control emerged weeds.* |
| **Permit**<br>halosulfuron | 75WG | 0.67 to 1.33 oz | **POST:** Can be applied to field corn from spike through layby stage. | • Controls sedges and certain annual broadleaf weeds (Tables 12 and 14).<br>• Registered for use on field corn and field corn grown for seed.<br>• *Do not* exceed two applications or 2.66 oz/A of Permit per season. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Permit (cont.)** | | | | • *Do not* harvest for forage or silage within 30 days of application; *do not* graze within 30 days of application.<br>• An NIS or a COC must be used.<br>• Permit will not control ALS-resistant weed species. |
| **Princep**<br>simazine | 4L<br>90WDG | 2 to 8 pt<br>1.1 to 4.4 lb | **Fall Burndown:** Apply after harvest but before winter annual weeds emerge and the ground freezes.<br>**EPP:** Apply up to 2 weeks before planting.<br>**PRE:** Apply before crop and weeds emerge. | • Controls annual grass and broadleaf weeds (Tables 12 and 14).<br>• Registered for use on corn.<br>• *Do not* exceed 2 qt/A of Princep 4L if Princep is used in the fall.<br>• *Do not* apply more than 8 pt/A or 4.4 lb/A per year.<br>• *Do not* graze treated areas. |
| **Prowl** or **Pendimax** | 3.3EC | 1.8 to 4.8 pt | **PRE:** Apply after planting but before crop and weeds emerge. | • Controls annual grasses and certain small-seeded broadleaf weeds (Table 12).<br>• Registered for use on field corn, sweet corn, seed corn, and popcorn.<br>• *Do not* apply PP or PPI.<br>• Plant corn at least 1.5 in. deep.<br>• Corn seed must be completely covered with soil.<br>• *Do not* exceed the maximum labeled rate for any soil type.<br>• *Do not* graze or feed forage from treated areas within 12 to 21 days of application (depends on formulation).<br>• Adjust rates according to soil texture and organic matter.<br>• *Will not control emerged weeds.* |
| **Prowl $H_2O$**<br>pendimethalin | 3.8 CS | 2.0 to 4.0 pt | **POST:** Apply to field corn up to 30 in. tall or the V8 stage, whichever is more restrictive. | |
| **Pursuit**<br>imazethapyr | 70DG | 1.44 oz | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 45 days before planting.<br>**PRE:** Apply before crop and weeds emerge.<br>**POST:** Apply after crop and weeds emerge. | • *Use only on* ***Clearfield*** *hybrids.*<br>• Controls grass and broadleaf weed species (Tables 19, 21, and 22).<br>• *Do not* make more than one application per growing season.<br>• *Do not* harvest for grain, forage, fodder, or silage within 45 days after application; *do not* graze within 45 days after application. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Pursuit (cont.)** | | | | • Check label for compatibility with soil insecticides.<br>• Include an adjuvant and a fertilizer solution for POST applications.<br>• Pursuit will not control ALS-resistant weed species. |
| **Pursuit Plus**<br>0.2 lb imazethapyr +<br>2.7 lb pendimethalin | 2.9EC | 2.5 pt | **PRE:** Apply after planting but before crop and weeds emerge.<br>**POST:** Apply after crop and weeds emerge. | • *Use only on* ***Clearfield*** *hybrids.*<br>• Controls grass and broadleaf weed species (Tables 19, 21, and 22).<br>• *Do not* apply PP or PPI.<br>• Plant corn at least 1.5 in. deep.<br>• Corn seed must be completely covered with soil.<br>• *Do not* harvest for grain, forage, fodder, or silage within 45 days after application; *do not* graze within 45 days after application.<br>• Check label for compatibility with soil insecticides.<br>• POST applications require an NIS and a fertilizer solution. |
| **Python WDG**<br>flumetsulam | 80WDG | 0.8 to 1.33 oz | **EPP:** Apply up to 30 days before planting.<br>**PPI:** Apply up to 30 days before planting.<br>**PRE:** Apply at or just after planting but prior to weed emergence. | • Controls broadleaf weeds (Table 14).<br>• *Do not* apply to sweet corn or popcorn.<br>• *Do not* exceed 1.4 oz/A of Python WDG per growing season.<br>• An interval of 85 days is required between application of Python WDG and harvest.<br>• *Do not* apply to soils with pH greater than 7.8.<br>• *Do not* use Python WDG on soils with less than 1.5% organic matter or unacceptable injury may occur.<br>• See Table 16 for compatibility with soil insecticides.<br>• Python will not control ALS-resistant weed species. |
| **Radius**<br>3.57 lb flufenacet +<br>0.43 lb isoxaflutole | 4SC | 7 to 28 fl oz | **EPP:** Apply up to 21 days before planting.<br>**PPI:** Apply up to 21 days before planting.<br>**PRE:** Apply before crop and weeds emerge. | • Controls annual broadleaf and grass weeds (Tables 12 and 14).<br>• *Do not* use on popcorn, sweet corn, or corn grown for seed.<br>• Radius is a restricted use pesticide (RUP).<br>• *Do not* make more than one application of Radius per season. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Radius (cont.)** | | | | • Read and observe all environmental precautions.<br>• Radius has some burndown activity; apply with a COC or an MSO.<br>• *Do not* apply to very sandy soils.<br>• Adjust rates according to soil texture, organic matter, and application timing. |
| **ReadyMaster ATZ**<br>2.0 lb atrazine +<br>1.5 lb a.e. glyphosate | 4CS | 1.5 to 2 qt | **PRE:** Apply up to 14 days before planting.<br>**POST:** Apply to corn from emergence up to 12 in. tall. | • Apply POST *only on glyphosate-resistant hybrids.*<br>• Controls grass and broadleaf weed species (Tables 9, 10, 12, 14, and 25).<br>• ReadyMaster ATZ is a restricted use pesticide (RUP).<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Adding additional adjuvants is not recommended. |
| **Resource**<br>flumiclorac | 0.86EC | 4 to 8 fl oz | **POST:** Apply to corn between the 2-leaf and 10-leaf stages.<br>**POST-directed:** Apply after corn has reached sufficient height for the spray to be directed beneath the corn leaves. | • Controls velvetleaf and certain other broadleaf weeds (Table 14).<br>• Registered for use on field corn.<br>• *Do not* apply more than 6 fl oz/A in a single broadcast application or more than a total of 8 fl oz/A of Resource per season.<br>• *Do not* graze animals on green forage or use as feed until at least 28 days after application.<br>• Applications must include a COC and a nitrogen source. |
| **Sencor**<br>metribuzin | 75DF | 2 to 5.33 oz<br><br>2 to 4 oz<br><br>2 to 4 oz | **EPP:** Apply from 10 to 30 days before planting.<br>**PRE:** Apply from 0 to 9 days before planting.<br>**POST:** Apply from crop emergence until just prior to tasseling. | • Controls certain grasses and broadleaf weeds (Table 21).<br>• **Soil applications:** *Do not* apply on coarse-textured soils with less than 1.5% organic matter.<br>• **Soil applications:** *Do not* apply more than 4 oz/A of Sencor on soils with less than 2% organic matter.<br>• **Soil applications:** *Do not* apply on soils having a pH of 7.0 or greater. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS – ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Sencor (cont.)** | | | | • **Soil applications:** Sencor can be used on hybrid seed-corn production fields if both inbred parents are known to have tolerance to Sencor.<br>• **POST applications:** *Do not* use COCs or any adjuvants containing vegetable or petroleum oils.<br>• **POST applications:** *Do not* use on sweet corn, popcorn, white corn, or corn grown for seed.<br>• **POST applications:** *Do not* apply when field corn is under stress.<br>• **POST applications:** *Do not* use on sand, loamy sand, or sandy loam soils that have less than 0.5% organic matter.<br>• *Do not* apply more than 5.33 oz/A of Sencor per growing season.<br>• *Do not* graze or harvest for silage or grain within 28 days after application. |
| **Shotgun**<br>2.25 lb atrazine +<br>1.0 lb a.e 2,4-D | 3.25L | 2 to 3 pt | **EPP:** Apply 7 to 14 days before planting.<br>**PRE:** Apply 5 to 7 days after planting but before corn emergence.<br>**EPOST:** Apply to corn from spike to the 4-leaf stage but before corn is 8 in. tall.<br>**POST-directed:** Apply to corn from 8 to 12 in. tall or the 5-leaf stage, whichever is more restrictive. | • Controls broadleaf weeds (Table 14).<br>• Shotgun is a restricted use pesticide (RUP).<br>• Registered for use on field corn.<br>• *Do not* make PP or PRE applications to medium- and fine-textured soils with less than 1% organic matter or to coarse-textured soils with less than 2% organic matter.<br>• *Do not* make PP or PRE applications unless corn is planted at least 1.5 in. deep.<br>• *Do not* make POST applications of Shotgun within 3 weeks of PP or PRE applications.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• This product contains 2,4-D; take precautions to avoid drift onto desirable legumes and broadleaf crops.<br>• Adjust rates according to soil texture and organic matter. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Spirit**<br>42.8% primisulfuron + 14.2% prosulfuron | 57WDG | 1 oz | **POST:** Apply to corn from 4 to 20 in. tall or the V6 stage, whichever is more restrictive.<br>**POST-directed:** Drop nozzles may be used on corn from 20 to 24 in. tall. | • Controls annual broadleaf and certain grass weeds (Tables 12 and 14).<br>• *Do not* apply to sweet corn or ornamental corn.<br>• *Do not* graze or feed forage from treated areas within 30 days after application.<br>• *Do not* harvest for silage within 40 days after application.<br>• *Do not* harvest for grain within 60 days after application.<br>• Apply with a COC or an NIS and a nitrogen source.<br>• Spirit will not control ALS-resistant weed species. |
| **Starane**<br>fluroxypyr | 1.5 EC | ⅔ pt | **POST:** Apply through the V5 growth stage. | • Controls certain annual and perennial broadleaf species.<br>• Do not make more than two applications or apply more than 1.33 pints per acre per season.<br>• Registered for use in field corn and sweet corn.<br>• *Do not* graze or harvest forage from treated areas within 47 days of application.<br>• *Do not* apply less than 90 days before grain harvest. |
| **Steadfast**<br>50% nicosulfuron + 25% rimsulfuron | 75WDG | 0.75 oz | **POST:** Apply to corn up to 20 in. tall or through the V6 stage, whichever is more restrictive. | • Controls grasses and certain broadleaf weed species (Tables 12 and 14).<br>• Registered for use in field corn.<br>• *Do not* apply to field corn grown for seed, popcorn, or sweet corn.<br>• See Table 16 for compatibility with soil insecticides.<br>• Must include a COC or an NIS; the addition of a nitrogen source is also required unless prohibited on tank-mix partner label.<br>• *Do not* apply more than 0.75 oz/A of Steadfast per year.<br>• *Do not* tank-mix with Basagran, Laddok, or 2,4-D.<br>• *Do not* tank-mix with other ALS-inhibiting herbicides unless recommended. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Steadfast (cont.)** | | | | • *Do not* graze or feed forage, hay, or straw within 30 days of applying Steadfast.<br>• Steadfast will not control ALS-resistant weed species. |
| **Steadfast ATZ**<br>2.7% nicosulfuron +<br>1.3% rimsulfuron +<br>85.3% atrazine | 89.3WDG | 14 oz | **POST:** Apply to corn up to 12 in. tall or through the V6 stage, whichever is more restrictive. | • Controls annual grasses and broadleaves.<br>• Registered for use in field corn.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Do not tank-mix with Basagran, Laddok S-12, or 2,4-D.<br>• Steadfast ATZ is a restricted use pesticide (RUP).<br>• Must include a COC or an NIS; the addition of an ammonium nitrogen is also required.<br>• *Do not* apply to field corn grown for seed, popcorn, or sweet corn.<br>• *Do not* tank-mix with other ALS-inhibiting herbicides unless recommended.<br>• *Do not* graze or feed forage, hay, or straw within 60 days of applying Steadfast ATZ. |
| **Stinger**<br>clopyralid | 3S | 0.25 to 0.67 pt | **POST:** Apply to corn from emergence up to 24 in. tall. | • Controls Canada thistle and other broadleaf weeds (Table 14).<br>• Registered for use on field corn, production seed corn, popcorn, and sweet corn.<br>• *Do not* exceed 0.25 lb a.i. of clopyralid/A or ⅔ pt of Stinger/A per year.<br>• Use of a spray adjuvant is not necessary but may increase control of certain broadleaf weeds. |
| **Surpass**<br>acetochlor | 6.4EC | 1.5 to 3.75 pt | **Fall:** Apply north of Illinois Route 136 after October 15.<br>**EPP:** Apply up to 30 days before planting.<br>**PPI:** Apply up to 14 days before planting.<br>*(continues)* | • Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12).<br>• Surpass is a restricted use pesticide (RUP).<br>• Registered for use on field corn, production seed corn, silage corn, and popcorn.<br>• *Read* and *observe* all environmental precautions. |

**Table 1. Corn herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Surpass (cont.)** | | | **PRE:** Apply after planting but before crop emergence. **POST:** Apply until corn reaches 11 in. tall. | • *Do not* apply more than 3.75 pt/A of Surpass per season. • Adjust rates according to soil texture and organic matter. • *Will not control emerged weeds.* |
| **TopNotch** acetochlor | 3.2CS | 2 to 3 qt | **Fall:** Apply north of Illinois Route 136 after October 15. **EPP:** Apply up to 40 days before planting. **PPI:** Apply up to 10 days before planting. **PRE:** Apply after planting but before crop emergence. **POST:** Apply to corn up to 11 in. tall. | • Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12). • TopNotch is a restricted use pesticide (RUP). • Registered for use on field corn, production seed corn, silage corn, and popcorn. • *Read* and *observe* all environmental precautions. • Adjust rates according to soil texture and organic matter. • *Will not control emerged weeds.* |
| **Yukon** 12.5% halosulfuron + 55% dicamba | 67.5WDG | 4 to 8 oz | **POST:** Apply to corn from spike up to 36 in. tall. **POST-directed:** Drop nozzles may be used on corn from spike to 36 in. tall. | • Controls broadleaf weeds and sedges (Tables 12 and 14). • Registered for use on field corn and field corn grown for seed. • *Do not* make more than two applications of Yukon per year. • *Do not* exceed 8 oz/A of Yukon per year. • Allow at least 2 weeks between applications. • *Do not* graze or harvest for feed until the crop reaches the ensilage (milk) stage, at least 30 days after application. • This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops. • The use of an NIS is required, but it can be replaced with a COC; a nitrogen source is recommended. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence, LPOST = late postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, ESO = ethylated seed oil, AMS = ammonium sulfate.

**Table 2. Sorghum herbicides (Read and follow label directions before using product.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **2,4-D Amine** (many trade names) | 3.8 lb a.e. (many) | 1 pt | **POST:** Apply to sorghum from 6 to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall. | • Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on grain sorghum (milo). • *Do not* treat during the boot stage, flowering, or dough stage. • *Do not* forage for feed fodder for 7 days after application. • Spray particles can drift and cause injury to susceptible plants. |
| **2,4-D Ester** (many trade names) | 3.8 lb a.e. (many) | 0.5 to 1 pt | **POST:** Apply to sorghum from 5 to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall. | • Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25). • Registered for use on grain sorghum (milo). • Use 0.75 to 1 pt/A for control of perennial weeds. • 2,4-D ester can volatilize if temperatures exceed 85°F. • *See "Remarks and limitations" for 2,4-D Amine.* |
| **AAtrex, Atrazine** atrazine | 4L 90DF | 0.5 to 2.0 lb a.i. | **EPP:** Apply up to 45 days before planting, except on coarse-textured soils. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to sorghum up to 12 in. tall. | • Controls annual broadleaf and certain grass weeds (Table 14). • Registered for use on sorghum and sorghum–sudan grass hybrids (grain and forage types). • Atrazine is a restricted use pesticide (RUP). • *Do not* apply more than 2.5 lb a.i. atrazine/A in a calendar year. • *Do not* apply more than 1.6 lb a.i. atrazine/A/application on highly erodible soils with less than 30% residue cover. • *Do not* apply more than 2.0 lb a.i. atrazine/A/application on soils that are not highly erodible or on highly erodible soils with at least 30% residue cover. • Risk of carryover is greater on soils with pH greater than 7.2. • POST applications should include a COC. |

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Aim** carfentrazone | 1.9EW | 0.5 fl oz | **Preplant Burndown:** Apply from 30 days prior to planting through sorghum emergence. **POST:** Apply to sorghum up to the 6-leaf stage. | • Controls some annual broadleaf weeds (Table 14).<br>• Registered for use on grain and forage sorghum.<br>• For broad-spectrum control, Aim will need to be tank-mixed.<br>• *Do not* apply more than 1.0 fl oz/A of Aim EW per season.<br>• The use of drop nozzles is recom-mended for POST applications to sorghum grown for seed.<br>• Must include an NIS.<br>• The use of a COC for POST applications is *not* recommended. |
| **Banvel** dicamba | 4L | 0.5 pt | **Preplant Burndown:** Apply to actively growing weeds at least 15 days prior to planting. **POST:** Apply to sorghum from spike to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall. | • Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25).<br>• Registered for use on sorghum (milo).<br>• Applications during periods of rapid growth may result in temporary leaning of plants or rolling of leaves.<br>• *Do not* graze or feed treated sorghum forage or silage prior to mature grain stage.<br>• Take precautions to avoid drift onto desirable legumes and broadleaf crops.<br>• *Do not* make more than one application per growing season. |
| **Basagran** bentazon | 4S | 1 to 2 pt | **POST:** Apply to actively growing weeds within the size limits listed on the label. | • Controls broadleaf weeds and sedges (Table 14).<br>• Registered for use on grain and forage sorghum.<br>• *Do not* graze treated sorghum for at least 12 days after application.<br>• *Do not* apply more than 2 pt/A of Basagran per year.<br>• *Do not* apply to sorghum that is heading or blooming.<br>• Include a COC and/or a spray-grade nitrogen source. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate / A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Bicep II Magnum**<br>2.4 lb *S*-metolachlor + 3.1 lb atrazine | 5.5L | 1.6 to 2.58 qt | **EPP:** Apply up to 45 days before planting, except on any coarse soil or on medium soils with less than 1% organic matter.<br>**PPI:** Apply up to 14 days before planting, except on any coarse soil or on medium soils with less than 1% organic matter.<br>**PRE:** Apply to the surface at planting but before crop and weeds emerge, except on any coarse soil or on medium soils with less than 1% organic matter. | • Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14).<br>• *Sorghum seed must be treated with a safener (Concep).*<br>• Bicep II Magnum is a restricted use pesticide (RUP).<br>• Registered for use on grain and forage sorghum.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• This product contains *S*-metolachlor; follow the use limitations listed under Dual II Magnum.<br>• *Do not* graze or feed forage from treated areas for 60 days following application.<br>• Adjust rates according to soil texture, organic matter, and application timing. |
| **Bicep Lite II Magnum**<br>3.33 lb *S*-metolachlor + 2.67 lb atrazine | 6L | 1.1 to 1.9 qt | **EPP:** Apply up to 45 days before planting, except on any coarse soil or on medium soils with less than 1% organic matter.<br>**PP:** Apply up to 14 days before planting, except on any coarse soil or on medium soils with less than 1% organic matter.<br>**PRE:** Apply to the surface at planting but before weeds and crop emerge, except on any coarse soil or on medium soils with less than 1% organic matter. | • Controls sedges, annual grasses, and broadleaf weeds (Tables 12 and 14).<br>• *Sorghum seed must be treated with a safener (Concep).*<br>• Bicep Lite II Magnum is a restricted use pesticide (RUP).<br>• Bicep Lite II Magnum contains less atrazine than Bicep II Magnum.<br>• *See "Remarks and limitations" for Bicep II Magnum.* |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Buctril** bromoxynil | 2EC | 1 to 1.5 pt<br><br>1 to 1.5 pt | **PRE:** Apply from before planting until just prior to emergence to control existing vegetation.<br>**POST:** Apply to sorghum from the 3-leaf stage until prior to the preboot stage. | • Controls certain annual broadleaf weeds (Table 14).<br>• Registered for use on sorghum (grain and forage).<br>• *Do not* harvest for feed or fodder and *do not* graze within 45 days after application.<br>• *Do not* exceed 2 pt/A of Buctril per season.<br>• *Do not* apply the 2 pt/A rate of Buctril to sorghum.<br>• Use of an adjuvant or liquid fertilizer may cause excessive leaf burn. |
| **Buctril + atrazine** 1.0 lb bromoxynil + 2.0 lb atrazine | 3L | 1.5 to 3 pt<br><br>1.5 to 3 pt | **PRE:** Apply from before planting until just prior to emergence to control existing vegetation.<br>**POST:** Apply to sorghum from the 3-leaf stage until prior to the preboot stage or 12 in. tall, whichever is more restrictive. | • Controls certain annual broadleaf weeds (Table 14).<br>• Buctril + atrazine is a restricted use pesticide (RUP).<br>• Registered for use on sorghum (grain and forage).<br>• *Do not* harvest for feed or fodder and *do not* graze within 45 days after application.<br>• *Do not* exceed 4 pt/A of Buctril + atrazine per season.<br>• *Do not* use on sandy or sandy loam soils or excessive crop injury may occur.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• Use of an adjuvant or liquid fertilizer may cause excessive leaf burn. |
| **Bullet** 2.5 lb alachlor + 1.5 lb atrazine | 4ME | 2.5 to 4.0 qt | **PPI:** Apply up to 7 days before planting.<br>**PRE:** Apply after planting but before crop and weeds emerge. | • Controls annual grass and broadleaf weeds (Tables 12 and 14).<br>• *Sorghum seed must be treated with a safener.*<br>• Bullet is a restricted use pesticide (RUP).<br>• Registered for use on grain sorghum (milo).<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• *Do not* make more than two applications of Bullet per year or exceed 6.4 qt/A of Bullet per year.<br>• *Do not* graze or harvest forage for 70 days following application.<br>• Adjust rates according to soil texture and organic matter. |

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate / A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Cinch**<br>*S*-metolachlor | 7.64EC | 1 to 1.67 pt | See Dual II Magnum application timings. | • Cinch contains the same active ingredient as Dual II Magnum; *see "Remarks and limitations" for Dual II Magnum.*<br>• *Will not control emerged weeds.* |
| **Cinch ATZ**<br>2.4 lb *S*-metolachlor + 3.1 lb atrazine | 5.5L | 1.3 to 2.6 qt | See Bicep II Magnum application timings. | • Cinch ATZ contains the same active ingredients as Bicep II Magnum; *see "Remarks and limitations" for Bicep II Magnum.* |
| **Cinch ATZ Lite**<br>3.33 lb *S*-metolachlor + 2.67 lb atrazine | 6L | 0.5 to 1.9 qt | See Bicep Lite II Magnum application timings. | • Cinch ATZ Lite contains the same active ingredients as Bicep Lite II Magnum; *see "Remarks and limitations" for Bicep Lite II Magnum.* |
| **Clarity**<br>dicamba | 4L | 0.5 pt | **Preplant Burndown:** Apply to actively growing weeds at least 15 days prior to planting.<br>**POST:** Apply to sorghum from spike to 8 in. tall.<br>**POST-directed:** Apply to sorghum from 8 to 15 in. tall. | • Controls annual and perennial broadleaf weeds (Tables 9, 10, 14, and 25).<br>• Registered for use on sorghum (milo).<br>• Applications during periods of rapid growth may result in temporary leaning of plants or rolling of leaves.<br>• *Do not* graze or feed treated sorghum forage or silage prior to mature grain stage.<br>• Take precautions to avoid drift onto desirable legumes and broadleaf crops. |
| **Dual II Magnum**<br>*S*-metolachlor | 7.64EC | 1 to 1.67 pt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 14 days before planting.<br>**PRE:** Apply before crop and weeds emerge. | • Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12).<br>• *Sorghum seed must be treated with a safener (Concep).*<br>• Registered for use on grain and forage sorghum.<br>• *Do not* make more than one application of Dual II Magnum per season.<br>• *Do not* graze or feed treated forage for 30 days after application.<br>• Adjust rates according to soil texture, organic matter, and application timing. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Expert**<br>1.74 lb *S*-metolachlor + 2.14 lb atrazine + 0.74 lb a.e. glyphosate | 4.88SC | 2.5 to 3.75 qt | **EPP:** Apply up to 30 days before planting.<br>**PRE:** Apply before crop emergence. | • Controls annual and perennial grasses and broadleaves.<br>• Expert is a restricted use pesticide (RUP).<br>• Registered for use on forage and grain sorghum.<br>• Sorghum seed must be treated with a safener (Concep).<br>• *Do not* apply to coarse-textured soils.<br>• *Do not* apply to medium- or fine-textured soils with less than 1% organic matter.<br>• *Do not* graze or feed forage from treated areas for 60 days after application.<br>• This product contains atrazine; follow the use limitations listed under atrazine. |
| **glyphosate**<br>(many trade names)<br>(See Table 8.) | Various formulations | See Table 8 for product rates. | **EPP Burndown:** Apply before planting to control existing vegetation.<br>**PRE Burndown:** Apply after planting but before crop emerges to control existing vegetation. | • Controls grass and broadleaf weed species (Tables 9, 10, 12, 14, and 25).<br>• Application rates vary with weed size, application timing, and formulation.<br>• Table 8 contains a list of glyphosate formulations.<br>• Check labels for individual product restrictions. |
| **G-Max Lite**<br>2.25 lb dimethenamid-P + 2.75 lb atrazine | 5L | 2.0 to 3.5 pt | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 2 weeks before planting.<br>**PRE:** Apply before crop and weeds emerge.<br>**POST:** Apply to sorghum up to 12 in. tall. | • Controls annual grasses and broadleaf weeds (Tables 12 and 14).<br>• *Sorghum seed must be treated with a safener.*<br>• Registered for use on grain sorghum.<br>• G-Max Lite is a restricted use pesticide (RUP).<br>• G-Max Lite contains less atrazine than Guardsman Max.<br>• *See "Remarks and limitations" for Guardsman Max.* |
| **Gramoxone Inteon**<br>paraquat | 2S | 2.0 to 4.0 pt | **EPP Burndown:** Apply before planting to control existing vegetation.<br>*(continues)* | • Controls existing vegetation (Tables 9 and 10).<br>• Gramoxone Inteon is a restricted use pesticide (RUP).<br>• *Do not* apply broadcast after crop emergence. |

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Gramoxone Inteon (cont.)** | | 1.0 to 2.0 pt | **PRE Burndown:** Apply after planting but before crop emerges to control existing vegetation. **POST-directed:** Apply when sorghum is at least 12 in. tall. | • *Do not* use around gardens, schools, recreational parks, or playgrounds. • Always add an NIS or a COC to the spray mixture. • Adjust rates according to weed sizes. |
| **Gramoxone Max** paraquat | 3S | 1.3 to 2.7 pt<br>0.7 to 1.3 pt | **EPP Burndown:** Apply before planting to control existing vegetation. **PRE Burndown:** Apply after planting but before crop emerges to control existing vegetation. **POST-directed:** Apply when sorghum is at least 12 in. tall. | • Controls existing vegetation (Tables 9 and 10). • Gramoxone Max is a restricted use pesticide (RUP). • *Do not* exceed 4 pt/A of Gramoxone Max per season. • *Do not* apply broadcast after crop emergence. • *Do not* use around gardens, schools, recreational parks, or playgrounds. • Always add an NIS or a COC to the spray mixture. • Adjust rates according to weed sizes. |
| **Guardsman Max** 1.7 lb dimethenamid-P + 3.3 lb atrazine | 5L | 2.5 to 4.6 pt | **EPP:** Apply up to 45 days before planting. **PPI:** Apply up to 2 weeks before planting. **PRE:** Apply before crop and weeds emerge. **POST:** Apply to sorghum up to 12 in. tall. | • Controls annual grasses and broadleaf weeds (Tables 12 and 14). • *Sorghum seed must be treated with a safener.* • Registered for use on grain sorghum. • Guardsman Max is a restricted use pesticide (RUP). • *Do not* apply to sweet or forage sorghum. • *Do not* apply to sorghum planted in coarse-textured soils. • This product contains atrazine; follow the use limitations listed under atrazine. • *Do not* graze or feed forage sorghum within 60 days after application. • *Do not* harvest grain or fodder within 80 days after application. • Adjust rates according to soil texture, organic matter, and cation-exchange capacity. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **IntRRo, Micro-Tech**<br>alachlor | 4EC, 4CS | 1.5 to 3.0 qt | **PPI:** Apply up to 7 days before planting.<br>**PRE:** Apply to the surface at planting, before crop and weeds emerge, and within 5 days after the last preplant tillage operation. | • Controls sedges, annual grasses, and certain small-seeded broadleaf weeds (Table 12).<br>• *Sorghum seed must be treated with a safener (Screen).*<br>• IntRRo and Micro-Tech are restricted use pesticides (RUPs).<br>• Registered for use on grain sorghum (milo).<br>• *Read* and *observe* all environmental precautions.<br>• *Do not* make more than two applications per year or exceed a total of 4 qt/A of IntRRo or Micro-Tech per year.<br>• *Do not* graze or harvest forage for 70 days following application of this product.<br>• Adjust rates according to soil texture and organic matter. |
| **Laddok S-12**<br>2.5 lb bentazon +<br>2.5 lb atrazine | 5L | 1.33 to 2.33 pt | **POST:** Apply to sorghum up to 12 in. tall. | • Controls broadleaf weeds and sedges (Table 14).<br>• Registered for use on grain and forage sorghum.<br>• Laddok is a restricted use pesticide (RUP).<br>• *Do not* make more than one application of Laddok per season.<br>• *Do not* apply to sorghum grown for seed.<br>• *Do not* apply to sorghum that is heading out or blooming.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• An adjuvant is required for consistent weed control. |
| **Marksman**<br>1.1 lb dicamba +<br>2.1 lb atrazine | 3.2L | 1.5 to 2.0 pt | **PRE:** May be applied at least 15 days before planting.<br>**EPOST:** Apply to sorghum from the 2-leaf to the 5-leaf stage (about 2 to 8 in. tall). | • Controls broadleaf weeds (Table 14).<br>• Marksman is a restricted use pesticide (RUP).<br>• Registered for use on sorghum.<br>• *Do not* apply to sorghum grown for seed.<br>• *Do not* graze or feed forage for 21 days following application.<br>• *Do not* harvest for 45 days following POST application. |

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Marksman (cont.)** | | | | • *Do not* exceed 3.5 pt/A of Marksman per season.<br>• *Do not* add crop oil after sorghum emergence; *do not* add a surfactant unless possible crop injury is acceptable.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops.<br>• Adjust rates according to soil texture and organic matter. |
| **Outlook**<br>dimethenamid-P | 6EC | 8 to 21 fl oz | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 2 weeks before planting.<br>**PRE:** Apply before crop and weeds emerge.<br>**POST:** Apply to sorghum up to 12 in. tall. | • Controls annual grasses and certain small-seeded broadleaf weeds (Table 12).<br>• *Sorghum seed must be treated with a safener.*<br>• Registered for use on grain sorghum.<br>• *Do not* apply to sweet or forage sorghum.<br>• *Do not* graze or feed forage sorghum within 60 days after application.<br>• *Do not* harvest grain or fodder within 80 days after application.<br>• Adjust rates according to soil texture, organic matter, and cation-exchange capacity.<br>• *Will not control emerged weeds.* |
| **Paramount**<br>quinclorac | 75DF | 5.3 to 8.0 oz | **PRE:** Apply prior to sorghum emergence.<br>**POST:** Apply to sorghum up to 12 in. tall. | • Controls certain annual grass and broadleaf species.<br>• Registered for use on grain sorghum.<br>• POST applications require the addition of MSO or COC; a nitrogen fertilizer also may be included.<br>• *Do not* apply more than 16 oz per acre per year.<br>• *Do not* plant crops other than wheat or sorghum for at least 10 months after application.<br>• *Do not* allow livestock to graze in treated areas.<br>• *Do not* feed treated forage, hay, silage, straw, or seed to livestock. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Permit** halosulfuron | 75WG | 0.67 to 1.0 oz | **POST:** Can be applied to sorghum from the 2-leaf through the layby stage (before grainhead emergence). | • Controls sedges and certain annual broadleaf weeds (Tables 12 and 14).<br>• Registered for use on grain sorghum (milo).<br>• *Do not* exceed 1.0 oz/A of Permit per season.<br>• *Do not* harvest for forage or silage and *do not* graze within 30 days of application.<br>• An NIS or a COC must be used.<br>• Permit will not control ALS-resistant weed species. |
| **ReadyMaster ATZ** 2.0 lb atrazine + 1.5 lb a.e. glyphosate | 4CS | 1.5 to 2 qt | **EPP:** Apply up to 14 days before planting. | • Controls grass and broadleaf weed species.<br>• ReadyMaster ATZ is a restricted use pesticide (RUP).<br>• Allow at least 60 days between application and harvest or grazing of sorghum.<br>• This product contains atrazine; follow the use limitations listed under atrazine. |
| **Sequence** 2.25 lb a.e. glyphosate + 3.0 lb *S*-metolachlor | 5.25EW | 2.5 to 4 pt | **EPP:** Apply up to 30 days before planting.<br>**PRE:** Apply before crop emergence. | • Controls annual and perennial grasses and broadleaves.<br>• Registered for use on grain and forage sorghum.<br>• *Sorghum seed must be commercially treated with Concep safener.*<br>• *Do not* exceed 3.5 pt/A on coarse-textured soils or 3.75 pt/A on medium-textured soils.<br>• *Do not* apply after sorghum begins to emerge. |
| **Shotgun** 2.25 lb atrazine + 1.0 lb a.e. 2,4-D | 3.25L | 2 pt | **EPOST:** Apply to sorghum from spike to the 4-leaf stage, but before sorghum is 8 in. tall.<br>**POST-directed:** Apply to sorghum at the 5-leaf stage, or to sorghum that is 8 to 12 in. tall. | • Controls broadleaf weeds (Table 14).<br>• Shotgun is a restricted use pesticide (RUP).<br>• Registered for use on sorghum.<br>• This product contains atrazine; follow the use limitations listed under atrazine.<br>• This product contains 2,4-D; take precautions to avoid drift onto desirable legumes and broadleaf crops.<br>• Sorghum is a sensitive crop and may be susceptible to injury from this product. |

**Table 2. Sorghum herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Starane** fluroxypyr | 1.5 EC | ⅔ pt | **PRE:** Apply prior to sorghum emergence. **POST:** Apply from the 3-leaf stage through the 7-leaf stage. **POST-directed:** Apply from the 8-leaf stage to boot. | • Controls certain annual and perennial broadleaf species. • Registered for use on grain sorghum. • *Do not* make more than 2 applications or apply more than 1.33 pt per acre per season. • *Do not* graze or harvest forage from treated areas within 40 days of application. • *Do not* apply less than 70 days before grain or stover harvest. |
| **Yukon** 12.5% halosulfuron + 55% dicamba | 67.5WDG | 4 to 6 oz | **POST:** Apply to sorghum from the 2-leaf stage up to 8 in. tall. **POST-directed:** Apply to sorghum from 8 to 15 in. tall. | • Controls broadleaf weeds and sedges (Tables 12 and 14). • Registered for use on grain sorghum (milo). • Applications during periods of rapid growth may cause temporary leaning of plants or rolling of leaves. • *Do not* exceed 6 oz/A of Yukon per year. • *Do not* graze or feed treated sorghum forage or silage prior to the mature grain stage. • *Do not* apply to sorghum grown for seed. • This product contains dicamba; take precautions to avoid drift onto desirable legumes and broadleaf crops. • The use of an NIS is required, but it can be replaced with a COC; a nitrogen source is recommended. |

EPP = early preplant, PP = preplant, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant.

**Table 3. Soybean herbicides (Read and follow label directions before using product.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **2,4-D** (many trade names) | 3.8 lb a.e. ester (many) | 1 to 2 pt | **Preplant Burndown:** Apply before soybean planting. | • Controls annual and perennial broadleaf weeds (Tables 9 and 10).<br>• *Do not* plant soybeans sooner than 7 days after application of up to 1 pt or sooner than 30 days after application of 2 pt.<br>• *Do not* use on sandy soils.<br>• Plant soybeans at least 1.5 to 2 in. deep; seed furrow should be completely closed. |
| **Aim** carfentrazone | 1.9EW | 0.25 fl oz | **EPP:** Apply up to 30 days before planting for burndown control.<br>**POST:** Apply from the V2 stage up to the V10 stage of soybean. | • Controls some annual broadleaf weeds (Table 14).<br>• Can provide some burndown of existing vegetation.<br>• POST applications require the addition of an NIS.<br>• *Do not* apply more than 0.023 lb a.i./A per season.<br>• *Do not* feed treated soybean forage or soybean hay to livestock.<br>• Will not control PPO-resistant waterhemp. |
| **Assure II** quizalofop | 0.88EC | 5 to 12 fl oz | **Preplant Burndown:** Apply 2.5 to 5 fl oz/A.<br>**POST:** Apply before soybean pod set and at least 80 days before harvest. | • Controls many annual and perennial grass weeds (Table 19).<br>• Preplant burndown applications must include a COC.<br>• POST applications require an NIS or a COC.<br>• *Do not* graze or feed treated soybean forage, hay, or straw to livestock.<br>• *Do not* apply within 80 days of harvest or more than 18 fl oz/A per season.<br>• *Do not* plant rotational grass crops within 120 days of application. |
| **Backdraft SL** 0.15 lb a.e. imazaquin + 0.884 lb a.e. glyphosate | 1.35L | 2.5 qt | **Fall:** Apply after harvest and prior to ground freeze.<br>**EPP:** Apply up to 45 days before planting.<br>**PRE:** Apply during or after planting but before soybeans emerge. | • Controls grass and broadleaf weeds when applied burndown or POST (Tables 19 and 22).<br>• All applications of Backdraft require the addition of a surfactant and ammonium sulfate.<br>• A tank-mix partner will be needed for residual grass control.<br>• Make only one application of Backdraft per season. |

*(continues)*

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Backdraft SL (cont.)** | | | **POST:** Apply only to *glyphosate-resistant* soybeans at least 90 days prior to harvest. | • *Do not* make POST applications to soybean varieties that are not ***glyphosate-resistant.*** • *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |
| **Basagran** bentazon | 4L | 1 to 3 pt | **POST:** Apply to actively growing weeds within the size limits listed on the label. | • Controls broadleaf weeds (Table 22). • Applications require a COC/MSO or a COC/MSO and UAN. • *Do not* apply more than 2 lb a.i. bentazon/A per season. • *Do not* graze or cut treated soybean fields for forage or hay for at least 30 days after application. |
| **Boundary** 5.25 lb *S*-metolachlor + 1.25 lb metribuzin | 6.5EC | 1.2 to 3 pt | **EPP:** Apply up to 30 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before soybeans emerge. | • Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • Can provide some burndown of existing vegetation. • Soil pH of 7.0 or higher increases the chance of soybean injury. • On soils with pH greater than 7.0, use only the 1.5 pt/A rate. • Treated soybean plants may be grazed or fed to livestock 40 days after the last application of Boundary. |
| **Canopy EX** 22.7% chlorimuron + 6.8% tribenuron | 29.5WDG | 1.1 to 3.3 oz | **Fall:** Apply after harvest and before ground freeze. **EPP:** Do not apply within 45 days of planting. | • Controls certain winter and summer annual broadleaf weeds. • The addition of 2,4-D ester will broaden the weed control spectrum. • Applications must include a COC or NIS; COC is the preferred additive. • *Do not* graze treated fields or harvest for forage or hay. |
| **Cinch** *S*-metolachlor | 7.64EC | 1 to 2 pt | See Dual II Magnum application timings. | • Cinch contains the same active ingredient as Dual II Magnum; *see "Remarks and limitations" for Dual II Magnum.* • *Will not control emerged weeds.* |

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Classic** chlorimuron | 25DG | 0.5 to 0.75 oz | **Fall:** Apply after harvest but before ground freezes. **EPP:** Apply before soybeans emerge. **POST:** Apply after the first trifoliolate has expanded and at least 60 days before soybean maturity. | • Controls broadleaf weeds (Table 22). • Can provide some burndown of existing vegetation; include a COC for burndown applications. • Higher application rates are labeled for fall and EPP applications. • POST applications require an NIS or a COC/MSO; ammonium nitrogen fertilizer is required for velvetleaf control. • *Do not* graze treated fields or harvest for forage or hay. |
| **Cobra or Phoenix** lactofen | 2EC | 6 to 12.5 fl oz<br>8 to 12.5 fl oz | **PRE:** Consult label for application rates. **POST:** Apply no later than 45 days before harvest, or after the R6 growth stage. | • Controls annual broadleaf weeds (Table 22). • POST applications require the addition of spray additives. Consult respective product labels for recommendations. • *Do not* exceed a total of 25 fl oz/A per season. • *Do not* graze or feed treated soybean forage to livestock or use soybean hay or straw for bedding. • Will not control PPO-resistant waterhemp. |
| **Command** clomazone | 3ME | 1.33 to 2.67 pt | **EPP:** Apply up to 30 days before planting. **PRE:** Apply before soybeans emerge. **PPI:** Incorporate no deeper than the top 1 to 2 in. of soil. | • Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • *Do not* apply Command 3ME within 1,200 feet of towns and housing developments, certain commercial fruit/nut or vegetable production areas, commercial greenhouses, or nurseries. • *Do not* allow livestock to graze on treated soybean plants. |
| **Define** flufenacet | 4SC | 8 to 14 fl oz | **EPP:** Apply up to 14 days before planting. **PPI:** Apply up to 14 days before planting. **PRE:** Apply before soybeans emerge. | • Controls annual grasses. • *Do not* apply more than 14 fl oz/A/season. • *Do not* graze or feed forage, hay, or straw to livestock. |

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Dual II Magnum** S-metolachlor | 7.64EC | 1 to 2 pt | **Fall:** Applications can be made north of Illinois Route 136 after October 31. **EPP:** Apply up to 30 to 45 days before planting. **PPI:** Apply and incorporate within 14 days of planting. **PRE:** Apply during or after planting but before crop and weeds emerge. **POST:** Apply from soybean emergence through the third trifoliolate stage. | • Controls annual grasses and certain broadleaf weeds (Tables 19 and 21). • *Do not* apply more than 2.5 pt of Dual II Magnum to soybeans during any one crop. • *Do not* apply more than 1.33 pt/A POST. • *Do not* graze or feed treated forage or hay from soybean treated POST. • *Will not control emerged weeds.* |
| **Extreme** 0.17 lb a.e. imazethapyr + 1.473 lb a.e. glyphosate | 2.17L | 3 pt | **Fall:** Apply after harvest and prior to ground freeze. **Burndown:** Apply prior to planting or preemergence. **POST:** Apply only to ***glyphosate-resistant*** soybean and at least 85 days before harvest. | • Controls grasses and broadleaf weeds when applied burndown or POST (Tables 19 and 22). • All applications of Extreme require the addition of a surfactant and AMS. • *Do not* apply Extreme POST to soybean varieties that are not ***glyphosate-resistant***. • Make only one application of Extreme per season. • *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |
| **FirstRate or Amplify** cloransulam | 84WDG | 0.3 to 0.75 oz | **EPP:** Apply within 2 weeks of planting for optimal results. **PPI:** Do not apply earlier than 4 weeks before planting. **PRE:** Apply within 2 days after planting for optimal results. **POST:** Apply to soybeans any time prior to the 50% flowering stage. | • Controls broadleaf weeds (Tables 21 and 22). • Can provide some burndown of existing vegetation; include a COC and a liquid nitrogen fertilizer for burndown applications. • POST applications require either an NIS, a COC/MSO, an NIS plus UAN, or a COC/MSO plus UAN. • *Do not* make more than one soil application during a single growing season. • *Do not* apply more than 0.6 oz/A as a POST application. |

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **FirstRate or Amplify (cont.)** | | | | • The cumulative application rate may not exceed 1.05 oz/A per season.<br>• *Do not* harvest soybeans for forage or hay for 14 days after application. |
| **Flexstar**<br>fomesafen | 1.88L | 0.75 to 1.6 pt | **POST:** Apply before soybeans bloom. | • Controls broadleaf weeds (Table 22).<br>• Make only one application of Flexstar in alternate years.<br>• POST applications require an NIS or a COC/MSO; nitrogen fertilizer also can be added.<br>• Maximum application rate north of Interstate 70 is 1.3 pt/A.<br>• Maximum application rate south of Interstate 70 is 1.6 pt/A.<br>• *Do not* graze treated areas or harvest for forage or hay.<br>• Will not control PPO-resistant waterhemp. |
| **Fusilade DX**<br>fluazifop | 2EC | 4 to 24 fl oz | **POST:** Apply before soybeans bloom. | • Controls many annual and perennial grass weeds (Table 19).<br>• Use 6 to 12 fl oz/A for most annual grass species; higher rates may be needed for perennial grass species.<br>• POST applications require an NIS or a COC; nitrogen fertilizer also can be added.<br>• *Do not* apply more than 32 oz/A per season.<br>• *Do not* graze treated areas or harvest for forage or hay.<br>• *Do not* plant rotational grass crops wthin 60 days of application. |
| **Fusion**<br>2 lb fluazifop + 0.56 lb fenoxaprop | 2.56EC | 4 to 14 fl oz | **POST:** Apply before soybeans bloom. | • Controls many annual and perennial grass weeds (Table 19).<br>• POST applications require an NIS or a COC; nitrogen fertilizer also can be added.<br>• *Do not* apply more than 24 oz/A per season.<br>• *Do not* graze treated areas or harvest for forage or hay.<br>• *Do not* plant rotational grass crops within 60 days of application. |

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate / A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Gangster**<br>51% flumioxazin<br>84% cloransulam | Co-Pack | 1.5 to 3 oz flumioxazin + 0.3 to 0.6 oz cloransulam | **Fall:** Apply after harvest and no earlier than October 15.<br>**EPP:** Apply up to 30 days before planting.<br>**PRE:** Apply before soybeans emerge. | • Controls broadleaf weeds (Table 21).<br>• *Do not* graze treated fields or feed treated forage or hay to livestock.<br>• *Do not* apply Gangster in fields where flufenacet, alachlor, metolachlor, or dimethenamid-containing products will be used. |
| **glyphosate**<br>(many trade names)<br>(See Table 8.) | Various formulations | See Table 8 for product rates. | **PRE:** Apply before, during, or after planting but prior to emergence of soybean varieties that are not glyphosate-resistant.<br>**POST:** Apply to ***glyphosate-resistant*** soybean throughout flowering.<br>**Spot treatment:** Apply prior to initial pod set.<br>**Preharvest:** Allow at least 7 to 14 days between application and harvest. | • Controls grasses and broadleaf weeds (Tables 19 and 22).<br>• Additive requirements can vary by formulation.<br>• Make POST applications only to ***glyphosate-resistant*** soybean. |
| **Gramoxone Inteon**<br>paraquat | 2S | 2.0 to 4 pt<br><br><br><br><br>4.5 to 8.0 fl oz<br><br><br>8.0 to 16 fl oz | **EPP Burndown:** Apply before planting to control existing vegetation.<br>**PRE Burndown:** Apply after planting but before crop emergence.<br>**POST-directed:** Apply when soybeans are at least 8 in. tall.<br>**Preharvest:** Do not apply within 15 days of harvest. | • Controls emerged grass and broadleaf weeds.<br>• Gramoxone Inteon is a restricted use pesticide (RUP).<br>• Applications require the addition of an NIS or a COC.<br>• *Do not* graze or harvest for forage or hay.<br>• *Do not* use around home gardens, schools, recreational parks, or playgrounds.<br>• *Do not* apply broadcast after crop emergence.<br>• Adjust rates according to weed size.<br>• **Preharvest applications to indeterminate varieties:** Apply when at least 65% of the seed pods have reached a mature brown color or when seed moisture is 30% or less. |

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Gramoxone Max** paraquat | 3L | 1.3 to 2.7 pt<br>3 to 5.3 fl oz<br>5.4 to 10.7 fl oz | **PRE:** Apply before, during, or after planting but before soybeans emerge.<br>**Directed application in crop:** Do not treat if soybeans are less than 8 in. tall.<br>**Preharvest:** Do not apply within 15 days of harvest. | • Controls emerged grass and broadleaf weeds.<br>• Applications require the addition of an NIS or a COC.<br>• Gramoxone Max is a restricted use pesticide (RUP).<br>• **Preharvest applications to indeterminate varieties:** Apply when at least 65% of the seed pods have reached a mature brown color or when seed moisture is 30% or less.<br>• *Do not* graze or harvest for forage or hay.<br>• *Do not* apply more than 4 pt/A per season. |
| **Harmony GT XP** thifensulfuron | 75DF | 0.083 oz | **PRE:** Apply for burndown of existing vegetation before soybeans emerge.<br>**POST:** Apply after the first trifoliolate has expanded fully. | • Controls broadleaf weeds (Table 22).<br>• Burndown and PRE application rates range from 0.3 to 0.6 oz/A; include an NIS.<br>• POST applications require an NIS or a COC; nitrogen fertilizer is also recommended for velvetleaf control.<br>• Apply no later than 60 days before harvest.<br>• *Do not* graze or feed treated soybean forage or hay to livestock. |
| **IntRRo, Micro-Tech** alachlor | 4EC, 4ME | 2 to 3 qt | **EPP:** Apply up to 30 days before planting.<br>**PPI:** Apply up to 7 days before planting.<br>**PRE:** Apply after planting and before soybean and weed emergence. | • Controls annual grasses and certain broadleaf weeds (Tables 19 and 21).<br>• IntRRo and Micro-Tech are restricted use pesticides (RUPs).<br>• *Do not* make more than one application per year or exceed 3 qt/A per year.<br>• *Do not* feed forage, hay, or straw to livestock. |
| **Outlook** dimethenamid-P | 6EC | 8 to 21 fl oz | **Fall:** Applications can be made north of Illinois Route 136 after October 1.<br>**EPP:** Apply up to 45 days before planting.<br>*(continues)* | • Controls annual grasses and certain broadleaf weeds (Tables 19 and 21).<br>• Make fall applications when soil temperatures at the 4-in. depth are sustained at less than 55°F but before ground freeze.<br>• POST applications will not control emerged weeds. |

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Outlook (cont.)** | | | **PPI:** Apply and incorporate up to 2 weeks before planting.<br>**PRE:** Apply after planting and before soybean emergence.<br>**POST:** Apply from first- to third-trifoliolate leaf stage. | • *Do not* apply more than 21 fl oz/A of Outlook per season.<br>• *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |
| **Poast Plus**<br>sethoxydim | 1SC | 0.75 to 3.0 pt | **Preplant Burndown:** Apply prior to planting for control of existing grass weeds.<br>**POST**: Apply to soybeans until 75 days prior to harvest. | • Controls many annual and perennial grass weeds (Table 19).<br>• Applications require the addition of a COC/MSO; nitrogen fertilizer may also be added.<br>• Only treated seed and hay may be used for livestock grazing or f eeding.<br>• *Do not* plant rotational grass crops within 30 days of application. |
| **Prowl** or **Pendimax** | 3.3EC | 1.2 to 3.6 pt | **Fall:** Apply after harvest between October 1 and December 31 and before ground freeze.<br>**EPP:** Apply up to 45 days before planting when tank-mixed or followed sequentially.<br>**PPI:** Apply up to 60 days before planting; incorporate 3.3EC formulation within 7 days of application.<br>**PRE:** Apply south of Interstate 80 only; apply at planting or up to 2 days after planting. | • Controls annual grasses and certain broadleaf weeds (Tables 19 and 21).<br>• *Do not* apply after soybeans emerge.<br>• Livestock can graze or be fed forage from treated soybean fields. |
| **Prowl $H_2O$**<br>pendimethalin | 3.8CS | 1.5 to 3.0 pt | | |

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Pursuit**<br>imazethapyr | 70DG<br>2AS | 1.44 oz<br>4 fl oz | **EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 45 days before planting.<br>**PRE:** Apply before or at planting.<br>**POST:** Apply before soybeans begin to bloom. | • Controls certain annual grasses and broadleaf weeds (Tables 19, 21, and 22).<br>• Make only one application of Pursuit per season.<br>• POST applications require the addition of an NIS plus UAN or a COC/MSO plus UAN.<br>• *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |
| **Pursuit Plus**<br>0.2 lb imaze-thapyr + 2.7 lb pendimethalin | 2.9EC | 2.5 pt | **Fall:** Apply after October 31 and before ground freeze.<br>**EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 45 days before planting.<br>**PRE:** Apply south of Interstate 80 only; apply at planting or up to 2 days after planting. | • Controls certain annual grass and broadleaf weeds (Tables 19 and 21).<br>• Make only one application of Pursuit Plus per season.<br>• *Do not* apply after soybeans emerge.<br>• *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |
| **Python**<br>flumetsulam | 80WDG | 0.8 to 1.33 oz | **EPP:** Apply up to 30 days before planting.<br>**PPI:** Apply up to 30 days before planting.<br>**PRE:** Apply during or after planting but prior to weed emergence. | • Controls annual broadleaf weeds (Table 21).<br>• Can provide some burndown of existing vegetation; include a COC for burndown applications.<br>• *Do not* apply to areas where soil pH is greater than 7.8 or to soils with less than 5% organic matter and pH less than 5.9.<br>• Maximum total flumetsulam active ingredient allowed per growing season is 0.07 lb/A.<br>• *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |
| **Raptor**<br>imazamox | 1AS | 4 to 5 fl oz | **POST:** Apply before soybeans bloom. | • Controls certain annual grasses and broadleaf weeds (Tables 19 and 22).<br>• Applications require the addition of an NIS plus UAN or a COC/MSO plus UAN.<br>• Make only one application of Raptor per season.<br>• *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Resource**<br>flumiclorac | 0.86EC | 4 to 12 fl oz | **POST:** Apply to soybeans up to 60 days before harvest. | • Controls annual broadleaf weeds (Table 22).<br>• POST applications require the addition of an NIS with or without a nitrogen fertilizer or a COC/MSO with or without a nitrogen fertilizer.<br>• Sequential applications may be made at least 14 days apart.<br>• *Do not* apply more than 12 fl oz/A in a single application.<br>• *Do not* apply more than 16 fl oz/A to soybeans during a single growing season.<br>• *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |
| **Rezult B&G**<br>B = 5 lb bentazon<br>G = 1 lb sethoxydim | Co-Pack | 1.6 pt of B + 1.6 pt of G | **POST:** Apply to soybeans up to 75 days before harvest. | • Controls grasses and broadleaf weeds (Tables 19 and 22).<br>• Applications require the addition of a COC plus a nitrogen fertilizer.<br>• *Do not* apply more than 3.2 pt/A in a single growing season.<br>• *Do not* graze treated soybean fields and *do not* feed treated soybean forage to livestock. |
| **Scepter**<br>imazaquin | 70DG | 1.4 to 2.8 oz | **Fall:** Apply after harvest and before ground freeze.<br>**EPP:** Apply up to 45 days before planting.<br>**PPI:** Apply up to 45 days before planting and incorporate within 7 days of application.<br>*(continues)*<br>**PRE:** Apply before soybeans emerge.<br>**POST:** Apply up to 90 days before harvest. | • Controls annual broadleaf weeds (Tables 21 and 22).<br>• Use the 1.4 oz rate for POST applications.<br>• POST applications require the addition of an NIS or a COC with or without a nitrogen fertilizer.<br>• *Do not* apply more than once per year.<br>• *Do not* graze or feed treated soybean forage, hay, or straw to livestock. |

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Select** clethodim | 2EC | 4 to 16 fl oz | **Preplant Burndown:** Apply 3 to 8 fl oz/A. **POST:** Apply to soybeans up to 60 days before harvest. | • Controls many annual and perennial grass weeds (Table 19). • Applications require the addition of a COC; nitrogen fertilizer may also be added. • *Do not* graze treated fields or feed treated forage or hay to livestock. • *Do not* plant rotational grass crops within 30 days of application. |
| **SelectMax** clethodim | 0.97EC | 8.0 to 32 fl oz | **POST:** Apply to soybean up to 60 days before harvest. | • Controls many annual and perennial grass weeds (Table 19). • Applications require the addition of a COC; nitrogen fertilizer may also be added. • Additives requirements may change based on tankmix partner. • *Do not* apply more than 64 fl oz per acre per season. • *Do not* graze treated fields or feed treated forage or hay to livestock. |
| **Sencor** metribuzin | 75DF | 2 oz to 1.16 lb | **EPP:** Apply up to 30 days before planting. **PRE:** Apply before soybean emergence. | • Controls annual broadleaf weeds (Table 21). • Can provide some burndown of existing vegetation; include a COC for burndown applications. • Treated vines may be grazed or fed to livestock 40 days after application. • *Do not* apply to sandy, sandy loam, or loamy sand soils with less than 2% organic matter. • *Do not* incorporate into the soil or apply more than once per season. |
| **Sequence** 2.25 lb a.e. glyphosate + 3.0 lb *S*-metolachlor | 5.25EW | 2.5 to 4 pt<br><br>2.5 to 3.5 pt | **EPP:** Apply up to 30 days before planting. **PRE:** Apply before crop emergence. **POST:** Apply only to *glyphosate-resistant* varieties through the third trifoliolate stage. | • Controls annual and perennial grasses and broadleaves. • Application rate is dependent on soil texture and organic matter content. • *Do not* feed treated soybean forage or hay for 30 days after a soil application. • *Do not* graze or feed treated forage or hay from soybean following a POST application. |

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Storm** 2.67 lb bentazon + 1.33 lb acifluorfen | 4SC | 1.5 pt | **POST:** Apply to soybeans up to 50 days before harvest. | • Controls annual broadleaf weeds (Table 22).<br>• Applications require the addition of a COC, an NIS, or a nitrogen fertilizer.<br>• *Do not* apply more than 3 pt/A of Storm per season.<br>• Sequential applications may be made at least 15 days apart.<br>• *Do not* use treated plants for livestock feed or forage. |
| **Synchrony XP** 21.5% chlorimuron + 6.9% thifensulfuron | 28.4DG | 1 to 3 oz<br><br>0.375 to 0.75 oz | **Preplant Burndown:** Apply up to 45 days before planting until just before soybean emergence.<br>**POST:** Apply after the first trifoliolate has opened until 60 days prior to soybean maturity. | • Controls broadleaf weeds (Table 22).<br>• Use the 0.75 oz/A rate for POST applications on ***STS soybean*** varieties only; use a COC/MSO and include ammonium nitrogen fertilizer.<br>• The 0.375 oz/A rate can be applied POST to non-STS soybean varieties; use an NIS and ammonium nitrogen fertilizer.<br>• *Do not* graze treated areas or harvest for forage or hay. |
| **Treflan HFP** trifluralin | 4EC | 1 to 2.5 pt | **Fall:** Apply and incorporate between October 15 and December 31.<br>**PPI:** Apply and incorporate prior to planting when soil is in good condition to be worked. | • Controls annual grasses and certain broadleaf weeds (Tables 19 and 21).<br>• *Do not* apply when soils are wet or subject to prolonged periods of flooding.<br>• Incorporation should be accomplished within 24 hours of application. |
| **Ultra Blazer** acifluorfen | 2SC | 0.5 to 1.5 pt | **Preplant Burndown:** Apply anytime before planting soybeans.<br>**POST:** Apply up to 50 days prior to soybean harvest. | • Controls annual broadleaf weeds (Table 22).<br>• Applications require the addition of an NIS, a COC, AMS, or UAN.<br>• *Do not* apply more than 2 pt/A of Ultra Blazer per growing season.<br>• Allow a minimum of 15 days between sequential applications.<br>• *Do not* use treated plants for feed or forage.<br>• Will not control PPO-resistant waterhemp. |

EPP = early preplant, PPI = preplant incorporated, PRE = preemergence, POST = postemergence.
COC = crop-oil concentrate, NIS = nonionic surfactant, MSO = methylated seed oil, UAN = urea-ammonium nitrate, AMS = ammonium sulfate.

**Table 3. Soybean herbicides (Read and follow label directions before using product.) (cont.)**

| Trade name | Formulation | Rate/A | Application timings | Remarks and limitations |
|---|---|---|---|---|
| **Valor SX** flumioxazin | 51WDG | 2 to 3 oz | **Fall:** Apply no earlier than October 15 but prior to ground freeze. **EPP:** No specific application timing information is provided on the label. **PRE:** Apply within 3 days of planting and before soybean emergence. | • Controls annual broadleaf weeds (Table 21). • Can provide some burndown of existing vegetation; include a COC/MSO for burndown applications. • *Do not* apply Valor in fields where products containing flufenacet, alachlor, metolachlor, or dimethenamid will be used. • *Do not* apply more than 3 oz/A of Valor per growing season. • *Do not* incorporate into the soil after application. • *Do not* graze treated fields or feed treated forage or hay to livestock. |

**Table 4. Herbicide and herbicide premix names and restrictions**

| Trade name(s) | Common name(s) | Restricted use pesticide[a] | Groundwater advisory[b] | Signal word[c] | Crop[d] |
|---|---|---|---|---|---|
| AAtrex, Atrazine | atrazine | Yes | Yes | Caution | C |
| Accent | nicosulfuron | — | — | Caution | C |
| Accent Gold | nicosulfuron + rimsulfuron + flumetsulam + clopyralid | — | Yes | Warning | C |
| Aim EW | carfentrazone-ethyl | — | — | Caution | C&S |
| Assure II | quizalofop | — | — | **Danger** | S |
| Backdraft | imazaquin + glyphosate | — | Yes | Caution | S |
| Balance PRO | isoxaflutole | Yes | Yes | Caution | C |
| Banvel, Clarity | dicamba | — | Yes | Warning, Caution | C |
| Basagran | bentazon | — | Yes | Caution | C&S |
| Basis | rimsulfuron + thifensulfuron | — | — | Caution | C |
| Basis Gold | rimsulfuron + nicosulfuron + atrazine | Yes | Yes | Caution | C |
| Beacon | primisulfuron | — | — | Caution | C |
| Bicep II Magnum, Cinch ATZ | *S*-metolachlor + atrazine + safener | Yes | Yes | Caution | C |
| Bicep Lite II Magnum, Cinch ATZ Lite | *S*-metolachlor + atrazine + safener | Yes | Yes | Caution | C |
| Boundary | *S*-metolachlor + metribuzin | — | Yes | Caution | S |
| Buctril | bromoxynil | — | — | Warning | C |
| Buctril + Atrazine | bromoxynil + atrazine | Yes | Yes | Caution | C |
| Bullet | alachlor + atrazine | Yes | Yes | Caution | C |
| Callisto | mesotrione | — | — | Caution | C |
| Canopy EX | chlorimuron + tribenuron | — | — | Caution | S |
| Celebrity Plus | nicosulfuron + dicamba + diflufenzopyr | — | Yes | Caution | C |
| Classic | chlorimuron | — | — | Caution | S |
| Cobra | lactofen | — | — | **Danger** | S |
| Command 3ME | clomazone | — | — | Caution | S |
| Define SC | flufenacet | — | Yes | Caution | C&S |
| Degree, Harness | acetochlor + safener | Yes | Yes | Caution, Warning | C |
| Degree Xtra, Harness Xtra | acetochlor + atrazine + safener | Yes | Yes | Caution | C |
| Distinct | dicamba + diflufenzopyr | — | Yes | Caution | C |
| Dual II Magnum, Cinch | *S*-metolachlor + safener | — | Yes | Caution | C&S |
| Equip | foramsulfuron + iodosulfuron | — | — | Caution | C |
| Expert | *S*-metolachlor + glyphosate + atrazine | Yes | Yes | Caution | C |
| Extreme | imazethapyr + glyphosate | — | Yes | Warning | S |
| FieldMaster | glyphosate + acetochlor + atrazine + safener | Yes | Yes | Caution | C |
| FirstRate, Amplify | cloransulam | — | Yes | Caution | S |
| Flexstar | fomesafen | — | Yes | Warning | S |
| FulTime, Keystone | acetochlor + atrazine + safener | Yes | Yes | Caution, Warning | C |
| Fusilade DX | fluazifop | — | — | Caution | S |
| Fusion | fluazifop + fenoxaprop | — | — | Caution | S |
| Gangster | flumioxazin + cloransulam | — | Yes | Caution | S |
| Gramoxone Max | paraquat | Yes | — | **Danger–Poison** | C&S |
| Guardsman Max, G-Max Lite | dimethenamid-P + atrazine | Yes | Yes | Caution, Warning | C |
| Harmony GT XP | thifensulfuron | — | — | Caution | S |
| Hornet WDG | flumetsulam + clopyralid | — | Yes | Warning | C |
| IntRRo, Micro-Tech | alachlor | Yes | Yes | **Danger**, Caution | S |

**Table 4. Herbicide and herbicide premix names and restrictions (cont.)**

| Trade name(s) | Common name(s) | Restricted use pesticide[a] | Groundwater advisory[b] | Signal word[c] | Crop[d] |
|---|---|---|---|---|---|
| Laddok S-12 | bentazon + atrazine | Yes | Yes | **Danger** | C |
| Lexar | *S*-metolachlor + mesotrione + atrazine | Yes | Yes | Caution | C |
| Liberty | glufosinate | — | — | Warning | C |
| Liberty ATZ | glufosinate + atrazine | Yes | Yes | Caution | C |
| Lightning | imazethapyr + imazapyr | — | Yes | Warning | C |
| Lumax | *S*-metolachlor + atrazine + mesotrione | Yes | Yes | Caution | C |
| Many | 2,4-D amine | — | Yes | **Danger** | C |
| Many | 2,4-D ester | — | — | Caution | C |
| Many | glyphosate (see Table 8) | — | — | Caution | C&S |
| Marksman | dicamba + atrazine | Yes | Yes | Caution | C |
| NorthStar | primisulfuron + dicamba | — | Yes | Caution | C |
| Option | foramsulfuron + safener | — | — | Caution | C |
| Outlook | dimethenamid-P | — | Yes | Warning | C&S |
| Permit | halosulfuron | — | — | Caution | C |
| Phoenix | lactofen | — | Yes | Caution | S |
| Poast Plus | sethoxydim | — | — | Caution | S |
| Princep, Simazine | simazine | — | Yes | Caution | C |
| Prowl, Pendimax | pendimethalin | — | — | Caution | C&S |
| Pursuit DG | imazethapyr | — | Yes | Warning | C&S |
| Pursuit Plus | pendimethalin + imazethapyr | — | Yes | Caution | C&S |
| Python | flumetsulam | — | Yes | Caution | C&S |
| Radius | flufenacet + isoxaflutole | Yes | Yes | Caution | C |
| Raptor | imazamox | — | — | Caution | S |
| ReadyMaster ATZ | glyphosate + atrazine | Yes | Yes | Caution | C |
| Resource | flumiclorac | — | — | Warning | C&S |
| Rezult B + G | bentazon + sethoxydim | — | Yes | **Danger** | S |
| Scepter | imazaquin | — | — | Caution | S |
| Select, Select Max | clethodim | — | — | Warning | S |
| Sencor | metribuzin | — | Yes | Caution | C&S |
| Sequence | *S*-metolachlor + glyphosate | — | Yes | Caution | S |
| Shotgun | atrazine + 2,4-D | Yes | Yes | **Danger** | C |
| Spirit | primisulfuron + prosulfuron | — | Yes | Caution | C |
| Starane | fluroxypyr | — | — | Warning | C |
| Steadfast | nicosulfuron + rimsulfuron | — | — | Caution | C |
| Steadfast ATZ | nicosulfuron + rimsulfuron + atrazine | Yes | Yes | Caution | C |
| Stinger | clopyralid | — | Yes | Caution | C |
| Storm | bentazon + acifluorfen | — | Yes | **Danger** | S |
| Surpass, TopNotch | acetochlor + safener | Yes | Yes | Warning, Caution | C |
| Synchrony XP | chlorimuron + thifensulfuron | — | — | Caution | S |
| Treflan HFP | trifluralin | — | — | Caution | S |
| Ultra Blazer | acifluorfen | — | Yes | **Danger** | S |
| Valor SX | flumioxazin | — | — | Caution | S |
| Yukon | halosulfuron + dicamba | — | Yes | Caution | C |

[a]To be applied by licensed applicator.
[b]Special precautions in sandy soils.
[c]Signal word = toxicity signal; indicates need for extra precautions. The signal words "**Danger**" and "Warning" often indicate pesticides that can irritate skin and eyes, necessitating protective clothing, gloves, and goggles or faceshield.
[d]C = corn; S = soybeans.

**Table 5a. Corn–sorghum herbicide recropping restrictions, months**

| Herbicide[a] | Comments | Field corn | Sorghum | Wheat | Oats | Rye | Alfalfa | Clover | Soybeans |
|---|---|---|---|---|---|---|---|---|---|
| *Acetochlor and its premixes* | | | | | | | | | |
| Degree, Harness | acetochlor | AT | NY | 4 | 2Y | 2Y | 2Y | 2Y | NY |
| Degree Xtra, Harness Xtra 5.6L | w/atrazine | AT | NY | 15 | 2Y | 2Y | 2Y | 2Y | NY |
| FulTime, Keystone, Keystone LA | w/atrazine | AT | NY | 15 | 2Y | 2Y | 2Y | 2Y | NY[b] |
| Surpass, TopNotch | acetochlor | AT | NY | 4 | 2Y | 2Y | 2Y | 2Y | NY |
| *Atrazine and its premixes; simazine* | | | | | | | | | |
| AAtrex, Atrazine | pH < 7.2 | AT | AT | NY | 2Y | NY | 2Y | 2Y | NY[b] |
| Bicep II Magnum, Cinch ATZ | w/*S*-metolachlor | AT | AT[c] | NY | 2Y | NY | 2Y | 2Y | NY[b] |
| Bicep Lite II Magnum, Cinch ATZ Lite | w/*S*-metolachlor | AT | AT[c] | NY | 2Y | NY | 2Y | 2Y | NY[b] |
| Buctril + Atrazine | w/bromoxynil | AT | AT | NY | 2Y | NY | 2Y | 2Y | NY |
| Bullet | w/alachlor | AT | AT[c] | NY | 2Y | NY | 2Y | 2Y | NY[b] |
| Expert | w/*S*-metolachlor + glyphosate | AT | AT[c] | NY | 2Y | NY | 2Y | 2Y | NY[b] |
| Guardsman Max, G-Max Lite | w/dimethenamid-P | AT | AT[c] | NY | 2Y | NY | 2Y | 2Y | NY |
| Laddok S-12 | w/bentazon | AT | AT | 15 | 15 | 15 | 18 | 18 | NY |
| Lexar | w/*S*-metolachlor + mesotrione | AT | NY | NY | 2Y | NY | 2Y | 2Y | NY |
| Liberty ATZ | w/glufosinate | AT | AT | NY[b] | 2Y | NY[b] | NY[b] | NY[b] | NY[b] |
| Lumax | w/*S*-metolachlor + mesotrione | AT | NY | 4.5 | NY | 4.5 | 18 | 18 | NY |
| Marksman | w/dicamba | AT | AT | 10 | 2Y | 10 | 2Y | 2Y | NY[b] |
| Princep, simazine | simazine | AT | NY | NY | 2Y | NY | 2Y | 2Y | NY |
| ReadyMaster ATZ | w/glyphosate | AT | AT | NY | 2Y | NY | 2Y | 2Y | NY[b] |
| Steadfast ATZ | w/nicosulfuron + rimsulfuron | AT | 10 | 10[b] | 18[b] | 10[b] | 18[b] | 18[b] | 10[b] |
| *Flumetsulam, clopyralid, and premix* | | | | | | | | | |
| Hornet WDG | w/clopyralid | AT | 12 | 4 | 4 | 4 | 10.5 | 26[Fba] | 10.5[e] |
| Python | flumetsulam | AT | 12 | 4 | 4 | 4 | 4 | 26[Fba] | AT |
| Stinger | clopyralid | AT | 10.5 | AT | AT | AT | 10.5 | 18 | 10.5[e] |
| *Isoxaflutole, flufenacet, and premix* | | | | | | | | | |
| Balance PRO | isoxaflutole | AT | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Define SC | flufenacet | AT | 12 | 12 | 12 | 12 | 12 | 12 | AT |
| Radius | flufenacet + isoxaflutole | AT | 12 | 12 | 18 | 12 | 12 | 18 | 6 |
| *Mesotrione* | | | | | | | | | |
| Callisto | mesotrione | AT | 10 | 120[d] | 120[d] | 120[d] | 10 | 18 | 10 |
| *Imazethapyr and its premixes* | | | | | | | | | |
| Lightning | w/imazapyr | 8.5[f] | 18 | 4 | 18 | 4 | 9.5 | 40[Fba] | 9.0 |
| Pursuit | imazethapyr | 8.5[f] | 18 | 3 | 18 | 4 | 4 | 40[Fba] | AT |
| Pursuit Plus | w/pendimethalin | 8.5 | 18 | 4 | 18 | 9.5 | 9.5 | 40[Fba] | AT |

**Table 5a. Corn–sorghum herbicide recropping restrictions, months (cont.)**

| Herbicide[a] | Comments | Field corn | Sorghum | Wheat | Oats | Rye | Alfalfa | Clover | Soybeans |
|---|---|---|---|---|---|---|---|---|---|
| *Sulfonylureas and their premixes* | | | | | | | | | |
| Accent | nicosulfuron | AT | 10[d] | 4 | 8 | 4 | 10 | 10 | 0.5 |
| Accent Gold | nicosulfuron + rimsulfuron + Hornet | AT | 12 | 4 | 8 | 4 | 10.5 | 26[Fba] | 10.5[e] |
| Basis | thifensulfuron + rimsulfuron | AT | 10 | 4 | 8 | 18 | 10 | 18 | 0.5 |
| Basis Gold | nicosulfuron + rimsulfuron + atrazine | AT | 10 | 10 | 18 | 10 | 18 | 18 | 10[b] |
| Beacon | primisulfuron | 0.5 | 8 | 3 | 8 | 3 | 8 | 18 | 8 |
| Celebrity Plus | dicamba + nicosulfuron + diflufenzopyr | 0.25 | 10[d] | 4 | 8 | 4 | 12 | 12 | 4 |
| Equip | foramsulfuron + iodosulfuron | 0.5 | 9 | 2 | 9 | 2 | 18 | 18 | 9 |
| NorthStar | primisulfuron + dicamba | 0.5 | 8 | 3 | 8 | 3 | 8 | 18 | 8 |
| Option | foramsulfuron | 0.25 | 2 | 2 | 2 | 2 | 2 | 2 | 0.5 |
| Permit | halosulfuron | 1 | 2 | 2 | 2 | 2 | 9 | 9 | 9 |
| Spirit | primisulfuron + prosulfuron | 1 | 10 | 3 | 3 | 3 | 18[g] | 18[g] | 10–18[h] |
| Steadfast | nicosulfuron + rimsulfuron | AT | 10[d] | 4 | 8 | 4 | 10 | 10 | 0.5 |
| Yukon | halosulfuron + dicamba | 1 | 2 | 2 | 2 | 2 | 9 | 9 | 9 |

[Fba] = field bioassay needed (see label); NY = next year; 2Y = second year; AT = anytime; d = days.
[a]Other corn herbicides have no significant recropping restrictions, but Banvel, Clarity, and 2,4-D have replanting limits for soybeans.
[b]2Y (second year) if applied after June 10 with high atrazine or Liberty ATZ and after July 1 with Basis Gold or Steadfast ATZ.
[c]Concep or Screen seed protectant needed.
[d]18 months if pH ≥ 7.5.
[e]18 months if < 15 inches of rainfall received and if soil has < 2% organic matter.
[f]Clearfield (CL) corn hybrids may be replanted anytime.
[g]Spirit: pH < 7.8, applied before July 1, rainfall > 12 inches within 5 months and > 1 inch within 4 weeks of application.
[h]I-70 to I-80: Spirit 10 months. North of I-80: Spirit 18 months.

**Table 5b. Soybean herbicide recropping restrictions, months**

| Herbicide | Comments | Field corn | Sorghum | Wheat | Oats | Rye | Alfalfa | Clover | Soybeans |
|---|---|---|---|---|---|---|---|---|---|
| *Chlorimuron and its premixes* | | | | | | | | | |
| Canopy EX[a] | w/tribenuron | 10 | 12 | 4 | 30 | 4 | 10 | 12 | AT |
| Classic | high chlorimuron | 9[b] | 9[b] | 3 | 3 | 3 | 12[b] | 12[b] | AT |
| Synchrony XP | w/thifensulfuron | 9[b] | 9[b] | 3 | 3 | 3 | 12[b] | 12[b] | AT |
| *Cloransulam and flumetsulam; cloransulam premix* | | | | | | | | | |
| FirstRate, Amplify | cloransulam | 9 | 9 | 3 | 9 | 30[Fba] | 9 | 30[Fba] | AT |
| Gangster | w/flumioxazin | 9 | 9 | 3 | 9 | 30[Fba] | 9 | 30[Fba] | AT |
| Python | flumetsulam | AT | 12 | 4 | 4 | 4 | 4 | 26[Fba] | AT |
| *Imazaquin and its premixes (Region 3 = north of Peoria)* | | | | | | | | | |
| Backdraft SL—Region 2[c] | w/glyphosate | 9.5[d] | 11 | 4 | 11 | 18 | 18 | 18 | AT |
| Backdraft SL—Region 3[c] | w/glyphosate | 18[d] | 11 | 18 | 18 | 18 | 18 | 18 | AT |
| Scepter—Region 2[c] | imazaquin | 9.5[d,e] | 11[e] | 3[e] | 11[e] | 18 | 18 | 18 | AT |
| Scepter—Region 3[c] | 0.5 rate, post | NY[d] | 11 | Fall[e] | NY[e] | 18 | 18 | 18 | AT |
| Scepter—Region 3[c] | imazaquin | 18 | 11 | 18 | 18 | 18 | 18 | 18 | AT |
| *Imazethapyr and its premixes* | | | | | | | | | |
| Extreme | w/glyphosate | 8.5[f] | 18 | 3 | 18 | 4 | 4 | 40 | AT |
| Pursuit | imazethapyr | 8.5[f] | 18 | 3 | 18 | 4 | 4 | 40 | AT |
| Pursuit Plus | w/pendimethalin | 8.5 | 18 | 4 | 18 | 9.5 | 9.5 | 40 | AT |
| *Metribuzin and its premix* | | | | | | | | | |
| Boundary | w/*S*-metolachlor | 8 | 12 | 4.5 | 12 | 12 | 4.5 | 12 | AT |
| Sencor | metribuzin | 4 | 12 | 4 | 12 | 12 | 4 | 12 | 4 |
| *Other active ingredients* | | | | | | | | | |
| Command 3ME | clomazone | 9 | 9 | 12 | 12[g] | 12[g] | 12[g] | 12[g] | AT |
| Flexstar | fomesafen | 10 | 18 | 4 | 4 | 4 | 18 | 18 | AT |
| Pendimax/Prowl | pendimethalin | NY | NY | 4 | NY | NY | NY | NY | AT |
| Raptor | imazamox | 8.5 | 9 | 3 | 9 | 4 | 9 | 18 | AT |
| Sequence | *S*-metolachlor + glyphosate | AT | AT[c] | 4.5 | 4.5 | 4.5 | 4 | 9 | AT |
| Treflan | trifluralin | NY | 12 | NY | 12 | 12 | NY | NY | AT |
| Valor SX | flumioxazin | 2[h] | 2[h] | 2[h] | 12 | 4 | 12[Fba] | 12 | AT |

[Fba] = field bioassay needed (see label); NY = next year; 2Y = second year; AT = anytime.
[a]Midwest states' rate, soil pH < 7.
[b]Extend 2 months if applied after August 1.
[c]See label for exact area and Region 3 (northern Illinois) full-use rate.
[d]10- to 15-inch annual rainfall is required, or use CL-corn hybrids.
[e]15 months if Scepter/Scepter sequence, but 9.5 months or NY for CL-corn hybrids.
[f]Clearfield (CL) corn hybrids may be replanted anytime.
[g]Cover crops may be planted anytime, but stand reductions may occur. Do not graze or harvest for forage for at least 9 months.
[h]30 days following applications of 2 ounces per acre or less.

**Table 6. Corn herbicide premixes, or co-packs, and equivalents.**

| Herbicide | Components (a.i./gal or lb) | If you apply (per acre) . . . | You have applied (a.i.) | An equivalent rate of |
|---|---|---|---|---|
| Accent Gold 78.1WDG | 0.054 lb nicosulfuron<br>0.054 lb rimsulfuron<br>0.514 lb clopyralid<br>0.159 lb flumetsulam | 3.5 oz | 0.012 lb nicosulfuron<br>0.012 lb rimsulfuron<br>0.11 lb clopyralid<br>0.035 lb flumetsulam | 0.25 oz Accent 75DF<br>0.012 lb a.i. rimsulfuron<br>4.8 fl oz Stinger 3S<br>0.69 oz Python 80WDG |
| Basis 75WDG | 0.50 lb rimsulfuron<br>0.25 lb thifensulfuron | 0.33 oz | 0.01 lb rimsulfuron<br>0.005 lb thifensulfuron | 0.01 lb a.i. rimsulfuron<br>0.11 oz Harmony GTXP 75DF |
| Basis Gold 89.5WDG | 0.0134 lb rimsulfuron<br>0.0134 lb nicosulfuron<br>0.8678 lb atrazine | 14 oz | 0.012 lb rimsulfuron<br>0.012 lb nicosulfuron<br>0.759 lb atrazine | 0.012 lb a.i. rimsulfuron<br>0.25 oz Accent 75DF<br>13.5 oz AAtrex 90DF |
| Bicep II Magnum 5.5L, Cinch ATZ | 2.40 lb *S*-metolachlor<br>3.1 lb atrazine | 2.1 qt | 1.26 lb *S*-metolachlor<br>1.63 lb atrazine | 0.66 qt Dual II Magnum 7.64EC<br>1.62 qt AAtrex 4L |
| Bicep Lite II, Magnum 6L, Cinch ATZ Lite | 3.33 lb *S*-metolachlor<br>2.67 lb atrazine | 1.5 qt | 1.25 lb *S*-metolachlor<br>1.00 lb atrazine | 0.65 qt Dual II Magnum 7.64EC<br>1.00 qt AAtrex 4L |
| Buctril + Atrazine 3L | 1.0 lb bromoxynil<br>2.0 lb atrazine | 2 pt | 0.25 lb bromoxynil<br>0.50 lb atrazine | 1 pt Buctril 2EC<br>1 pt AAtrex 4L |
| Bullet 4CS | 2.5 lb alachlor<br>1.5 lb atrazine | 4 qt | 2.5 lb alachlor<br>1.5 lb atrazine | 2.5 qt Micro-Tech 4CS<br>1.5 qt AAtrex 4L |
| Celebrity Plus 70WDG | 0.42 lb dicamba<br>0.17 lb diflufenzopyr<br>0.106 lb nicosulfuron | 4.7 oz | 0.125 lb dicamba<br>0.049 lb diflufenzopyr<br>0.031 lb nicosulfuron | 4.0 oz Distinct 70WDG<br><br>0.66 oz Accent 75DF |
| Degree Xtra 4.04CS | 2.7 lb acetochlor<br>1.34 lb atrazine | 3 qt | 2.025 lb acetochlor<br>1.0 lb atrazine | 2.13 qt Degree 3.8CS<br>1 qt AAtrex 4L |
| Distinct 70WDG | 0.2 lb diflufenzopyr<br>0.5 lb dicamba | 6 oz | 0.075 lb diflufenzopyr<br>0.188 lb dicamba | 0.075 lb a.i. diflufenzopyr<br>6 fl oz Clarity 4S |
| Equip 32WDG | 0.30 lb foramsulfuron<br>0.02 lb iodosulfuron | 1.5 oz | 0.028 lb foramsulfuron<br>0.0019 lb iodosulfuron | 1.28 oz Option 35WDG<br>0.0019 lb a.i. iodosulfuron |
| Expert 4.9SC | 1.74 lb *S*-metolachlor<br>2.14 lb atrazine<br>0.74 lb a.e. glyphosate | 3 qt | 1.31 lb *S*-metolachlor<br>1.61 lb atrazine<br>0.555 lb a.e. glyphosate | 1.37 pt Dual II Magnum 7.64EC<br>1.6 qt AAtrex 4L<br>1.48 pt Glyphosate 3L |
| FieldMaster 4.06S | 2.0 lb acetochlor<br>1.5 lb atrazine<br>0.56 lb a.e. glyphosate | 4 qt | 2.0 lb acetochlor<br>1.5 lb atrazine<br>0.56 lb a.e. glyphosate | 2.3 pt Harness 7EC<br>3.0 pt AAtrex 4L<br>1.5 pt Roundup 3L |
| FulTime 4CS | 2.4 lb acetochlor<br>1.6 lb atrazine | 4 qt | 2.4 lb acetochlor<br>1.6 lb atrazine | 3.00 qt TopNotch 3.2CS<br>1.6 qt AAtrex 4L |
| G-Max Lite 5L | 2.25 lb dimethenamid-P<br>2.75 lb atrazine | 3.0 pt | 0.84 lb dimethenamid-P<br>1.0 lb atrazine | 18 fl oz Outlook 6EC<br>2 pt AAtrex 4L |
| Guardsman Max 5L | 1.7 lb dimethenamid-P<br>3.3 lb atrazine | 4.0 pt | 0.85 lb dimethenamid-P<br>1.65 lb atrazine | 18 fl oz Outlook 6EC<br>3.3 pt AAtrex 4L |
| Harness Xtra 5.6L | 3.1 lb acetochlor<br>2.5 lb atrazine | 5.0 pt | 1.94 lb acetochlor<br>1.56 lb atrazine | 2.21 pt Harness 7E<br>3.12 pt AAtrex 4L |

**Table 6. Corn herbicide premixes, or co-packs, and equivalents (cont.)**

| Herbicide | Components (a.i./gal or lb) | If you apply (per acre) . . . | You have applied (a.i.) | An equivalent rate of |
|---|---|---|---|---|
| Hornet WDG<br>68.5WDG | 0.185 lb flumetsulam<br>0.5 lb a.e. clopyralid | 4 oz | 0.046 lb flumetsulam<br>0.125 lb clopyralid | 0.93 oz Python 80WDG<br>5.3 fl oz Stinger 3S |
| Keystone 5.25L | 3.0 lb acetochlor<br>2.25 lb atrazine | 2.7 qt | 2.03 lb acetochlor<br>1.52 lb atrazine | 2.5 pt Surpass 6.4EC<br>3.0 pt AAtrex 4L |
| Keystone LA 5.5L | 4 lb acetochlor<br>1.5 lb atrazine | 2 qt | 2 lb acetochlor<br>0.75 lb atrazine | 2.5 pt Surpass 6.4EC<br>1.5 pt AAtrex 4L |
| Laddok S-12 5L | 2.5 lb bentazon<br>2.5 lb atrazine | 1.67 pt | 0.52 lb bentazon<br>0.52 lb atrazine | 1.0 pt Basagran 4S<br>1.0 pt AAtrex 4L |
| Lexar 3.7L | 1.74 lb *S*-metolachlor<br>1.74 lb atrazine<br>0.224 lb mesotrione | 3.5 qt | 1.52 lb *S*-metolachlor<br>1.52 lb atrazine<br>0.196 lb mesotrione | 1.6 pt Dual II Magnum 7.64EC<br>3 pt AAtrex 4L<br>6.27 fl oz Callisto 4SC |
| Liberty ATZ 4.3SC[a] | 3.3 lb atrazine<br>1.0 lb glufosinate | 40 fl oz | 1.03 lb atrazine<br>0.313 lb glufosinate | 32 fl oz AAtrex 4L<br>24 fl oz Liberty 1.67L |
| Lightning 70DG[b] | 0.525 lb imazethapyr<br>0.175 lb imazapyr | 1.28 oz | 0.042 lb imazethapyr<br>0.014 lb imazapyr | 0.96 oz Pursuit 70DG<br>0.896 fl oz Arsenal 2AS |
| Lumax 3.95L | 2.68 lb *S*-metolachlor<br>0.268 lb mesotrione<br>1.0 lb atrazine | 3.0 qt | 2.01 lb *S*-metolachlor<br>0.20 lb mesotrione<br>0.75 lb atrazine | 1.0 qt Dual II Magnum 7.64EC<br>6.4 fl oz Callisto 4SC<br>0.75 qt AAtrex 4L |
| Marksman 3.2L | 1.1 lb dicamba<br>2.1 lb atrazine | 3.5 pt | 0.48 lb dicamba<br>0.92 lb atrazine | 0.96 pt Banvel 4S<br>1.84 pt AAtrex 4L |
| NorthStar 47.4WDG | 0.075 lb primisulfuron<br>0.399 lb dicamba | 5 oz | 0.023 lb primisulfuron<br>0.125 lb dicamba | 0.50 oz Beacon 75WDG<br>4.00 fl oz Banvel 4S |
| Radius 4SC | 3.57 lb flufenacet<br>0.43 lb isoxaflutole | 20 fl oz | 0.558 lb flufenacet<br>0.067 lb isoxaflutole | 17.9 fl oz Define 4SC<br>2.15 fl oz Balance PRO 4SC |
| ReadyMaster ATZ<br>4CS[c] | 2 lb atrazine<br>1.5 lb a.e. glyphosate | 2 qt | 1 lb atrazine<br>0.75 lb a.e. glyphosate | 2 pt AAtrex 4L<br>2 pt Roundup 3L |
| Shotgun 3.25F | 2.25 lb atrazine<br>1 lb a.e. 2,4-D | 3 pt | 0.84 lb atrazine<br>0.375 lb a.e. 2,4-D | 1.68 pt AAtrex 4L<br>0.6 pt Salvo 5E |
| Spirit 57WDG | 0.428 lb primisulfuron<br>0.142 lb prosulfuron | 1 oz | 0.027 lb primisulfuron<br>0.009 lb prosulfuron | 0.57 oz Beacon 75WDG<br>0.25 oz Peak 57WDG |
| Steadfast 75WDG | 0.5 lb nicosulfuron<br>0.25 lb rimsulfuron | 0.75 oz | 0.023 lb nicosulfuron<br>0.012 lb rimsulfuron | 0.5 oz Accent 75DF<br>0.012 lb a.i. rimsulfuron |
| Steadfast ATZ<br>89.3WDG | 0.027 lb nicosulfuron<br>0.013 lb rimsulfuron<br>0.853 lb atrazine | 14 oz | 0.024 lb nicosulfuron<br>0.011 lb rimsulfron<br>0.746 lb atrazine | 0.5 oz Accent 75DF<br>0.011 lb a.i. rimsulfron<br>0.83 lb AAtrex 90DF |
| Yukon 67.5WDG | 0.125 lb halosulfuron<br>0.50 lb dicamba | 4 oz | 0.03 lb halosulfuron<br>0.125 lb dicamba | 0.67 oz Permit 75WSG<br>4 fl oz Banvel 4S |

[a]Use only on Liberty Link (glufosinate-resistant) corn hybrids.
[b]Use only on Clearfield (CL) corn hybrids.
[c]Use only on glyphosate-resistant hybrids.

**Table 7. Soybean herbicide premixes, or co-packs, and equivalents**

| Herbicide | Components (a.i./gal or lb) | If you apply (per acre) . . . | You have applied (a.i.) | An equivalent rate of |
|---|---|---|---|---|
| Backdraft SL 1.35L[a] | 0.15 lb a.e. imazaquin<br>0.884 lb a.e. glyphosate | 2.5 pt | 0.094 lb a.e. imazaquin<br>0.55 lb a.e. glyphosate | 2.14 oz Scepter 70DG<br>1.47 pt Roundup 3L |
| Boundary 6.5EC | 5.25 lb *S*-metolachlor<br>1.25 lb metribuzin | 2.5 pt | 1.64 lb *S*-metolachlor<br>0.391 lb metribuzin | 1.72 pt Dual Magnum 7.62EC<br>12.5 fl oz Sencor 4L |
| Canopy EX 29.5WDG | 0.227 lb chlorimuron<br>0.068 lb tribenuron | 1.1 oz | 0.016 lb chlorimuron<br>0.005 lb tribenuron | 1.0 oz Classic 25DF<br>0.1 oz Express XP 75DF |
| Extreme 2.17L[a] | 0.17 lb imazethapyr<br>1.473 lb a.e. glyphosate | 3 pt | 0.063 lb imazethapyr<br>0.552 lb a.e. glyphosate | 4 fl oz Pursuit 2AS<br>1.47 pt Roundup 3L |
| Fusion 2.56EC | 2 lb fluazifop<br>0.56 lb fenoxaprop | 8 fl oz | 0.125 lb fluazifop<br>0.035 lb fenoxaprop | 8 fl oz Fusilade DX 2EC<br>4.48 fl oz Puma 1EC |
| Gangster V&FR (co-pack) | 0.51 lb flumioxazin<br>0.84 lb cloransulam | 3 oz<br>0.6 oz | 0.096 lb flumioxazin<br>0.032 lb cloransulam | 3 oz Valor SX 51WDG<br>0.6 oz FirstRate 84WDG |
| Pursuit Plus 2.9EC | 0.2 lb imazethapyr<br>2.7 lb pendimethalin | 2.5 pt | 0.063 lb imazethapyr<br>0.84 lb pendimethalin | 4 fl oz Pursuit 2AS<br>2 pt Prowl 3.3EC |
| Rezult B&G (co-pack) | B = 5.0 lb bentazon<br>G = 1.0 lb sethoxydim | 1.6 pt<br>1.6 pt | 1.00 lb bentazon<br>0.20 lb sethoxydim | 2.0 pt Basagran 4S<br>1.6 pt Poast Plus 1E |
| Sequence 5.25L | 3.0 lb *S*-metolachlor<br>2.25 lb a.e. glyphosate | 3 pt | 1.13 lb *S*-metolachlor<br>0.84 lb a.e. glyphosate | 1.18 pt Dual Magnum 7.62EC<br>26 fl oz Touchdown Total 4.17L |
| Storm 4S | 2.67 lb bentazon<br>1.33 lb acifluorfen | 1.5 pt | 0.50 lb bentazon<br>0.25 lb acifluorfen | 1 pt Basagran 4S<br>1 pt Blazer 2S |
| Synchrony XP 28.4DG[b] | 0.215 lb chlorimuron<br>0.069 lb thifensulfuron | 0.75 oz | 0.01 lb chlorimuron<br>0.003 lb thifensulfuron | 0.64 oz Classic 25DF<br>0.068 oz Harmony GT XP 75DF |

[a]Use postemergence only on glyphosate-resistant varieties.
[b]Use only on STS (sulfonylurea-tolerant) varieties at this rate.

**Table 8. Glyphosate formulations and product equivalents**

| Trade name | Company | Active ingredient/ acid equivalent per gallon or pound | Product rate equivalent to 0.375 lb a.e. | 0.56 lb a.e. | 0.75 lb a.e. | 1.13 lb a.e. | Crop[a] |
|---|---|---|---|---|---|---|---|
| | | | ..... *fl oz* ..... | | | | |
| Cornerstone | Agriliance | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Cornerstone Plus | Agriliance | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Gly Star 5 | Albaugh, Inc. / Agri Star | 5.4 lb a.i./4 lb a.e. | 12 | 18 | 24 | 36 | C&S |
| Gly Star Original | Albaugh, Inc. / Agri Star | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Gly Star Plus | Albaugh, Inc. / Agri Star | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| ClearOut 41 Plus | Chemical Product Technologies, LLC | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Glyfos | Cheminova | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Glyfos X-TRA | Cheminova | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Durango | DowAgro | 5.4 lb a.i./4 lb a.e. | 12 | 18 | 24 | 36 | C&S |
| Glyphomax XRT | DowAgro | 5.4 lb a.i./4 lb a.e. | 12 | 18 | 24 | 36 | C&S |
| Rattler | Helena | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Rattler Plus | Helena | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Glyphosate 41% | Helm Agro USA | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Gly-Flo | Micro Flo | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Honcho | Monsanto | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Honcho Plus | Monsanto | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Roundup Original | Monsanto | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Roundup Original II | Monsanto | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Roundup Original Max | Monsanto | 5.5 lb a.i./4.5 lb a.e. | 11 | 16 | 22 | 32 | C&S |
| Roundup UltraMax | Monsanto | 5 lb a.i./3.68 lb a.e. | 13 | 20 | 26 | 39 | C&S |
| Roundup UltraMax II | Monsanto | 5.5 lb. a.i./4.5 lb a.e. | 11 | 16 | 22 | 32 | C&S |
| Roundup Weathermax | Monsanto | 5.5 lb a.i./4.5 lb a.e. | 11 | 16 | 22 | 32 | C&S |
| Credit | Nufarm | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Credit Extra | Nufarm | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Touchdown | Syngenta | 3.7 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Touchdown HiTech | Syngenta | 6.16 lb a.i./5 lb a.e. | 10 | 14 | 19 | 29 | C&S |
| Touchdown Total | Syngenta | 5.14 lb a.i./4.17 lb a.e. | 11.5 | 17 | 23 | 35 | C&S |
| Buccaneer | Tenkoz | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Buccaneer Plus | Tenkoz | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Mirage | UAP | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Mirage Plus | UAP | 4 b a.i./ 3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Gly-4 | Universal Crop Protection Alliance | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |
| Gly-4 Plus | Universal Crop Protection Alliance | 4 lb a.i./3 lb a.e. | 16 | 24 | 32 | 48 | C&S |

[a]Labeled for use in glyphosate-resistant corn hybrids (C) and/or soybean varieties (S).

**Table 9. Control ratings for herbicides to control existing vegetation in no-till corn and soybean**

| | | Winter annual grasses | | | | | Winter annual broadleaves | | | | | Summer annuals | | | | | | Perennials | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Herbicide | Crop[a] | Barley, little | Bluegrass, annual | Brome, downy | Ryegrass, annual | Rye or wheat cover | Chickweed, common | Henbit/purple deadnettle | Horseweed (marestail) | Mustards | Prickly lettuce | Foxtail, giant | Fleabane, daisy or annual | Lambsquarters, common | Ragweed, common | Ragweed, giant | Smartweed, Pennsylvania | Alfalfa | Dandelion, common | Clover, read | Vetch, hairy |
| Balance PRO | C | — | — | 6 | — | 5 | 8 | 6 | 7 | 8 | 8 | 8 | — | 8 | 8 | 6 | 8 | 0 | 0 | 6 | 0 |
| Balance PRO + atrazine | C | — | 8 | 7 | 6 | 6 | 9 | 8 | 9 | 8 | 9 | 8 | 7 | 9 | 9 | 9 | 9 | 4 | 6 | 6 | 7 |
| Basis | C | 8 | 8 | 8 | — | 6 | 7 | 8 | 6 | 9 | 9 | 9 | — | 9 | 6 | 8 | 9 | 5 | 8 | — | — |
| 2,4-D ester[b] | C&S | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 8 | 9 | 8 | 0 | 6 | 9 | 9 | 8 | 7 | 6 | 8 | 8 | 9 |
| Clarity, Banvel[c] | C&S | 0 | 0 | 0 | 0 | 0 | 9 | 7 | 7 | 7 | 9 | 0 | 8 | 9 | 9 | 9 | 9 | 8 | 9 | 7 | 9 |
| 2,4-D + Clarity or Banvel[b,c] | C&S | 0 | 0 | 0 | 0 | 0 | 8 | 6 | 8 | 9 | 9 | 0 | 8 | 9 | 9 | 9 | 8 | 8 | 9 | 8 | 9 |
| 2,4-D + glyphosate[b] | C&S | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 6 | 9 | 9 | 9 | 8 | 6 | 8 | 8 | 8 |
| glyphosate[d] | C&S | 9 | 9 | 9 | 9 | 8 | 9 | 7 | 7 | 8 | 7 | 9 | 5 | 8 | 7 | 8 | 7 | 5 | 6 | 5 | 6 |
| glyphosate[e] | C&S | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 8 | 9 | 6 | 9 | 9 | 9 | 8 | 6 | 7 | 7 | 7 |
| FieldMaster | C | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 7 | 9 | 9 | 8 | 9 | 6 | 7 | 7 | 4 |
| Gramoxone Max | C&S | 7 | 9 | 7 | 7 | 6 | 9 | 8 | 6 | 7 | 6 | 8 | 5 | 8 | 8 | 7 | 6 | 3 | 6 | 4 | 7 |
| Gramoxone Max + atrazine | C | 9 | 9 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 7 | 9 | 9 | 9 | 9 | 4 | 7 | 6 | 8 |
| atrazine | C | 9 | 9 | 7 | 6 | 6 | 9 | 9 | 8 | 9 | 9 | 7 | 7 | 9 | 9 | 9 | 9 | 4 | 6 | 4 | 7 |
| Marksman | C | 9 | 9 | 8 | 5 | 5 | 9 | 9 | 9 | 9 | 9 | 5 | 6 | 9 | 9 | 9 | 9 | 8 | 9 | 7 | 9 |
| Sencor | C&S | 8 | — | 7 | 5 | 4 | 9 | 8 | 6 | 8 | 8 | 5 | — | 7 | 7 | 6 | 8 | 3 | 5 | 6 | 5 |
| Canopy EX + 2,4-D[b] | S | 4 | 4 | 4 | 4 | 4 | 9 | 8 | 8 | 9 | 9 | 6 | 8 | 9 | 9 | 8 | 9 | 5 | 8 | 8 | 8 |
| Valor SX | S | — | — | — | 0 | — | 9 | 7 | 0 | 8 | 0 | 0 | — | 8 | 5 | 5 | 0 | 0 | 0 | 0 | 0 |
| Extreme | S | 9 | 9 | 9 | 9 | 9 | 9 | 8+ | 7+ | 9 | 7+ | 9 | — | 9 | 9 | 9 | 9 | 6 | 7 | 7 | 7 |
| Backdraft SL | S | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 7+ | 9 | 8 | 9 | — | 9 | 9 | 9 | 8 | 6 | 7 | 7 | 7 |
| Expert | C | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 7 | 9 | 9 | 8 | 9 | 6 | 7 | 7 | 4 |

9 = excellent, 8 = good, 7 = fair, 6 = poor, < 5 = unsatisfactory, — = no information available

[a]Labeled for burndown applications in corn (C) or soybean (S).

[b]Soybean herbicide applications require a 7-day interval between planting and application for 1 pt or less and a 30-day interval for applications of 1 to 2 pt or more.

[c]Soybean herbicide applications require a 14-day interval between planting and application for 8 fl oz or less and a 28-day interval for applications of 8 to 16 fl oz or more.

[d]Glyphosate rate 0.375 lb a.e. (see Table 8 for a listing of glyphosate formulations).

[e]Glyphosate rate 0.75 lb a.e.

**Table 10. Control of perennial grass and legume sods before no-till crop production**

| Herbicide | Rate/ acre | Alfalfa | Blue-grass | Brome, smooth | Clover, red | Fescue, tall | Orchard-grass | Quack-grass | Timothy |
|---|---|---|---|---|---|---|---|---|---|
| glyphosate, fall | 1.5 lb a.e.[a] | **8** | **9+** | **9** | **9** | **9** | **9** | **9** | **9** |
| glyphosate, fall | 0.75 lb a.e.[a] | 7 | **9** | 7 | 7 | 7 | **8** | **9** | **9** |
| + 1 pt 2,4-D | | **8** | **9** | 6 | **9** | 6 | 7 | **8** | **8** |
| + 0.5 pt Banvel | | **8** | **9** | 6 | **9** | 6 | 7 | **8** | **8** |
| + 1 pt Banvel | | **9** | **9** | 6 | **9** | 6 | 7 | **8** | **8** |
| glyphosate, fall + spring | 0.75/0.75 lb a.e.[a] | **8** | **9+** | **9+** | **9** | **9** | **9** | **9** | **9** |
| glyphosate, spring | 1.5 lb a.e.[a] | 6 | **9** | **8** | 7 | 7 | 7 | **9** | **8** |
| glyphosate, spring | 0.75 lb a.e.[a] | 5 | **8** | 6 | 5 | 6 | 6 | 7 | 7 |
| + 1 pt 2,4-D | | 7 | **8** | 5 | **8** | 5 | 5 | 6 | 7 |
| + 0.5 pt Banvel | | **8** | **8** | 5 | **9** | 5 | 5 | 6 | 7 |
| Gramoxone Max, spring | 2.7 pt | N | 6 | 4 | 6 | 7 | 4 | 4 | 6 |
| Gramoxone Max, spring | 1.3 pt | N | 5 | N | 5 | 5 | N | N | 5 |
| + 2 lb atrazine | | 5 | 9 | 7 | **8** | **8** | 7 | 7 | **8** |

**9** = excellent, **8** = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

[a]See Table 8 for a listing of glyphosate formulations and product rates.

**Table 11. Corn herbicides: Preplant or preemergence rates per acre**

| Herbicide | Unit | 1% OM sandy loam[a] | 1–2% OM silt loam[b] | 3–4% OM silty clay loam[c] | 5–6% OM silty clay[c] |
|---|---|---|---|---|---|
| Atrazine 4L | qt | 2.0 | 2.0 | 2.0 | 2.0 |
| Atrazine 90DF | lb | 2.2 | 2.2 | 2.2 | 2.2 |
| Balance PRO 4SC | fl oz | No | 1.88–3.0[d] | 2.5–3.75 | 2.25–3.75 |
| Banvel 4S | pt | No[e] | No[e] | 1.0 | 1.0 |
| Bicep II Magnum 5.5L | qt | 1.3 | 1.6 | 2.1 | 2.6 |
| Bicep Lite II Magnum 6L | qt | 0.9 | 1.1 | 1.5 | 1.9 |
| Bullet 4L | qt | 2.5 | 3.0 | 4.0 | 4.5 |
| Callisto 4SC | fl oz | 6–7.7 | 6–7.7 | 6–7.7 | 6–7.7 |
| Cinch 7.64EC | pt | 1.0 | 1.33 | 1.67 | 2.0 |
| Cinch ATZ 5.5L | qt | 1.3 | 1.6 | 2.1 | 2.6 |
| Cinch ATZ Lite 6L | qt | 0.9 | 1.1 | 1.5 | 1.9 |
| Clarity 4S | pt | No[e] | No[e] | 1.0 | 1.0 |
| Define 4SC | fl oz | 15 | 19 | 22 | 25 |
| Degree 3.8CS | pt | 2.25–3.25[g] | 3.25–4.25 | 4.25–5 | 4.25–5 |
| Degree Xtra 4.04CS | qt | 2.9[g] | 2.9–3.7 | 3.2–3.7 | 3.2–3.7 |
| Dual II Magnum 7.64EC | pt | 1.0 | 1.33 | 1.67 | 2.0 |
| Expert 4.9SC | qt | 2.5–3.7 | 3–3.75 | 3–3.75 | 3–3.75 |
| FieldMaster 4.06S | qt | 3.5–5 | 4–5 | 4–5 | 4–5 |
| FulTime 4L | qt | 2.5[g] | 3.0 | 4.0 | 5.0 |
| G-Max Lite 5L | pt | 2.0 | 2.5 | 3.0 | 3.5 |
| Guardsman Max 5L | pt | 3.0 | 4.0 | 4.6 | 4.6 |
| Harness 7EC | pt | 1.5[g] | 2.0 | 2.5 | 2.75 |
| Harness Xtra 5.6L | qt | 1.4[g] | 2.0 | 2.5 | 3.0 |
| Hornet WDG 68.5WDG | oz | 4.0 | 5.0 | 5.0 | 5.0 |
| IntRRo 4EC | qt | 2.0 | 2.25 | 2.75 | 3.25 |
| Keystone 5.25L | qt | 2.2[g] | 2.4 | 2.6 | 3.1 |
| Keystone LA 5.5L | qt | 1.6[g] | 1.8 | 1.9 | 2.7 |
| Lexar 3.7L | qt | 3 | 3 | 3.5 | 3.5 |
| Lumax 3.95L | qt | 2.5 | 2.5 | 3.0 | 3.0 |
| Marksman 3.3L | pt | No[e] | No[e] | 3.5 | 3.5 |
| Micro-Tech 4CS | qt | 2.0 | 2.25 | 2.75 | 3.25 |
| Outlook 6EC | fl oz | 12–14 | 14–16 | 18–21 | 18–21 |
| Partner 65WG | lb | 3.0 | 3.5 | 4.0 | 5.0 |
| Princep or simazine 90DF | lb | 2.2 | 2.6 | 3.3 | 4.0 |
| Prowl or Pendimax 3.3EC | pt | 2.0 | 3.0 | 4.0 | 4.8 |
| Prowl $H_2O$ 3.8CS | pt | 2.0 | 3.0 | 4.0 | 4.0 |
| Pursuit Plus[h] 2.9EC | pt | 2.5 | 2.5 | 2.5 | 2.5 |
| Python 80WDG | oz | 0.8[f] | 1.0[f] | 1.25 | 1.33 |
| Radius 4SC | fl oz | 7–16 | 9–18 | 14–28 | 19–28 |
| Surpass 6.4E | pt | 1.5[g] | 2.0 | 2.5 | 3.0 |
| TopNotch 3.2CS | qt | 2.0[g] | 2.25 | 2.5 | 3.0 |

OM = organic matter in the soil.
No = not labeled for use on this soil type.

**Table 11. Corn herbicides: Preplant or preemergence rates per acre (cont.)**

[a]Characteristic of most sandy soils in Illinois.
[b]Characteristic of many Illinois soils south of Interstate 70.
[c]Characteristic of many "prairie soils" in northern Illinois.
[d]To use these rates the OM needs to be greater than 1.5%.
[e]If planted to no-till corn, may use 0.5 pt Banvel or 2 pt Marksman.
[f]May cause crop injury on this soil.
[g]Do not use if groundwater is within 30 ft of surface.
[h]Use only with Clearfield (CL) corn hybrids.

**Table 12. Corn herbicides: Grass and nutsedge control ratings**

| | Annuals | | | | | | | | Perennials | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Herbicide | Barnyardgrass | Crabgrass | Cupgrass, woolly | Foxtail, giant | Foxtail, yellow | Panicum, fall | Sandbur | Shattercane | Johnsongrass | Muhly, wirestem | Nutsedge, yellow | Quackgrass | Corn response |
| *Soil-applied* | | | | | | | | | | | | | |
| Define | 9 | 9 | 7 | 9 | 9 | 9 | 7 | 5 | N | N | 7 | N | 1+ |
| **Degree, Harness** | **9** | **9** | **7+** | **9** | **9** | **9** | **7** | **5** | **N** | **N** | **8** | **N** | **1+** |
| Dual II Magnum/ Cinch | 9 | 9 | 7 | 9 | 9 | 9 | 6 | 5 | N | N | 8 | N | 1 |
| **Outlook** | **9** | **9** | **7** | **9** | **9** | **9** | **6** | **5** | **N** | **N** | **7+** | **N** | **1+** |
| Micro-Tech | 9 | 9 | 7 | 9 | 9 | 9 | 6 | 5 | N | N | 7+ | N | 1+ |
| **Surpass, TopNotch** | **9** | **9** | **7+** | **9** | **9** | **9** | **7** | **5** | **N** | **N** | **8** | **N** | **1+** |
| Pendimax/Prowl | 8+ | 8+ | 8 | 8+ | 9 | 8+ | 8 | 7 | N | N | N | N | 1+ |
| **Balance PRO** | **8** | **7** | **8** | **8** | **6** | **8** | **6** | **5** | **N** | **5** | **N** | **N** | **2** |
| Radius | 9 | 9 | 8 | 9 | 9 | 9 | 6 | 5 | N | 5 | 3 | N | 2 |
| **Atrazine** | **7+** | **5** | **4** | **7** | **7** | **N** | **6** | **N** | **N** | **6** | **6** | **7** | **0** |
| Simazine | 8 | 7 | 4 | 8 | 8 | 7 | 6 | 4 | N | 6 | 4 | 6 | 0 |
| *Postemergence* | ..... *See Table 13 for maximum grass sizes* ..... | | | | | | | | | | | | |
| Accent or Celebrity Plus | 8+ | 5 | 8 | 8+ | 8+ | 8+ | 8 | 9 | 8+ | 7 | 6 | 8+ | 1+ |
| **Accent Gold** | **8+** | **6** | **7** | **8+** | **8** | **8** | **8** | **8+** | **7** | **6** | **5** | **7** | **2** |
| Basis | 8 | 6 | 5 | 8 | 8 | 7+ | 6 | 8 | 4 | 5 | 4 | 4 | 2 |
| **Basis Gold** | **8+** | **6** | **7** | **8+** | **8** | **8** | **8** | **8+** | **7** | **6** | **5** | **7** | **2** |
| Beacon | 4 | 4 | N | 6 | 5 | 7+ | 6 | 9 | 7+ | 5 | 6 | 8 | 2 |
| **Equip** | **8+** | **5** | **5** | **8** | **7** | **8** | **8** | **9** | **8** | **7+** | **4** | **8** | **2** |
| Option | 8+ | 5 | 6 | 8+ | 8+ | 8+ | 8 | 9 | 8+ | 8 | N | 8 | 1+ |
| **Steadfast** | **8+** | **6** | **7** | **8+** | **8** | **8+** | **8** | **9** | **8** | **6** | **5** | **8** | **2** |
| Steadfast ATZ | 8+ | 7 | 7 | 8+ | 8 | 8+ | 8 | 9 | 8 | 6 | 5 | 8 | 2 |
| **Lightning**[a] | **8** | **7+** | **8+** | **8+** | **8** | **8** | **8** | **9** | **7** | **5** | **6** | **5** | **1+** |
| Atrazine + oil | 7 | 5 | 6 | 7 | 7 | 4 | 6 | N | N | 5 | 7 | 6 | 1 |
| **Liberty ATZ**[b] | **7** | **7** | **8+** | **8+** | **7** | **7** | **7** | **8** | **6** | **7** | **6** | **5** | **1** |
| Liberty[b] | 7 | 6 | 8 | 8 | 7 | 9 | 7 | 7 | 5 | 6 | 6 | 6 | 1 |
| **ReadyMaster ATZ**[c] | **9** | **9** | **9** | **9** | **9** | **9** | **9** | **9** | **9** | **8+** | **7** | **8+** | **1** |
| glyphosate[c,d] | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8+ | 7 | 8+ | 1 |
| **Spirit** | **N** | **N** | **N** | **4** | **4** | **4** | **4** | **8+** | **6** | **N** | **5** | **6** | **1+** |
| NorthStar | N | N | N | 4 | 4 | 4 | 4 | 8+ | 6 | N | 5 | 6 | 1+ |
| **Permit** | **N** | **N** | **N** | **N** | **N** | **N** | **N** | **N** | **N** | **N** | **9** | **N** | **1** |
| Yukon | N | N | N | N | N | N | N | N | N | N | 9 | N | 1+ |
| **Laddok S-12** | **N** | **N** | **N** | **N** | **N** | **N** | **N** | **N** | **N** | **N** | **8** | **N** | **1** |
| Callisto | N | 7+ | N | N | N | N | N | N | N | N | N | N | 1+ |

9 = excellent, 8 = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.
Corn response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.
[a]Use only with Clearfield (CL) corn hybrids.
[b]Use only with Liberty Link (glufosinate-resistant) corn hybrids.
[c]Use only with glyphosate-resistant corn hybrids.
[d]See Table 8 for a listing of glyphosate formulations registered for use on glyphosate-resistant corn hybrids.

**Table 13. Corn "post-grass" herbicides: Maximum weed sizes**

| | | Annual grasses | | | | | | | | | | | Perennial weeds | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Herbicide | Rate / A | Barnyardgrass | Corn[a], volunteer | Crabgrass | Cupgrass, woolly | Foxtail, giant | Foxtail, yellow | Panicum, fall | Sandbur | Shattercane | Signalgrass, broadleaf | Johnsongrass, seedling | Johnsongrass | Quackgrass | Nutsedge, yellow | Thistle, Canada | Wirestem, muhly |
| | | *Maximum size (height or length of lateral) in inches for given rate.* | | | | | | | | | | | | | | | |
| Accent | ⅔ oz | 4 | — | — | 4 | 4 | 4 | 4 | 3 | 12 | 2 | 12 | 18 | 10 | — | — | — |
| Accent Gold | 2.9 oz | 3 | — | 1 | 1* | 3 | 3 | 3 | 2 | 6* | — | 8 | — | 8* | 2* | 4* | — |
| Basis | ⅓ oz | 2 | — | — | 1* | 2 | 2 | 2 | — | 4* | — | — | — | — | — | — | — |
| Basis Gold | 14 oz | 3 | — | 1 | 1* | 3 | 3 | 3 | 2 | 6* | 2 | 8 | — | 8* | 2* | 4* | — |
| Beacon | 0.76 oz | — | — | — | — | 2* | 2* | 2 | 4* | 12 | — | 12 | 16 | 8 | 4* | 9* | — |
| Callisto | 3.0 fl oz | — | — | 2 | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Celebrity Plus | 4.7 oz | 4 | — | — | 4 | 4 | 4 | 4 | 3 | 12 | 2 | 12 | 18 | 10 | — | — | — |
| Equip | 1.5 oz | 4 | — | 2 | 2 | 3 | 3 | 3 | 2 | 8 | 2 | 8 | 8 | 6 | — | 3 | 6 |
| NorthStar | 5.0 oz | — | — | — | — | 3* | 3* | 3* | 4* | 12 | — | 12* | 16* | 8* | 4* | 6* | — |
| Option | 1.5 oz | 4 | — | 2 | 2 | 3 | 3 | 3 | 2 | 12 | 2 | 16 | 16 | 10 | — | — | 10 |
| Spirit | 1.0 oz | — | — | — | — | — | 3* | — | — | 12 | — | 12* | 16* | 8* | — | 9* | — |
| Steadfast | 0.75 oz | 4 | — | 1 | 3 | 4 | 4 | 4 | 2 | 6 | 2 | 12 | 12 | 8 | 4* | 4* | 4* |
| Steadfast ATZ | 14 oz | 4 | — | 1 | 3 | 4 | 4 | 4 | 2 | 6 | 2 | 12 | 12 | 8 | 4* | 4* | 4* |
| **Herbicides requiring specially designated corn hybrids** | | | | | | | | | | | | | | | | | |
| Liberty (LL) | 28 fl oz | 3 | 10 | 3[b] | 6 | 6 | 3[b] | 3 | * | 6 | 4 | 6 | * | — | — | — | — |
| | 34 fl oz | 4 | 12 | 4[b] | 8 | 8 | 4[b] | 4 | 3[b] | 8 | 5 | 8 | *[c] | *[c] | — | *[c] | *[c] |
| Liberty ATZ | 40 fl oz | * | * | 3 | 6 | 4 | 2 | 2 | * | 6 | 3 | 4 | — | — | — | — | — |
| (LL) | 48 fl oz | 2 | 10 | 3 | 8 | 4 | 3 | 3 | * | 8 | 4 | 6 | *[c] | *[c] | — | *[c] | *[c] |
| Lightning (CL) | 1.28 oz | 3 | 12 | 3 | 3 | 6 | 3 | 3 | 1 | 8 | 8 | 8 | 8* | 3* | 3* | 3* | — |
| glyphosate[d] | 0.75 lb a.e. | 6 | 20 | 12 | 12 | 20 | 20 | 12 | 12 | 20 | 6 | 18 | 12 | 8 | 6 | — | > 8 |
| (RR) | 1.13 lb a.e. | 9 | 20 | 12 | 12 | 20 | 20 | 12 | 12 | 20 | 9 | 24 | 12 | 8 | 6 | — | > 8 |
| ReadyMaster ATZ (RR) | 2.0 qt | 2 | — | 2 | 4 | 4 | 4 | 2 | 4 | 2 | 2 | 4 | 4 | 4 | — | 4 | 4 |

— = Maximum size not specified on label.
*Suppression or partial control.
[a]Volunteer corn that is not resistant to the herbicide.
[b]Prior to tillering.
[c]Sequential application of 28 fl oz of Liberty provides some control.
[d]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant corn hybrids. Maximum weed heights listed above are from the Roundup Weathermax label. Check individual glyphosate labels for maximum weed heights.

**Table 14. Corn herbicides: Broadleaf weed–control ratings**

| Herbicide | Burcucumber | Cocklebur | Jimsonweed | Kochia | Lambsquarters | Morningglories, annual | Nightshade, eastern black | Pigweeds | Ragweed, common | Ragweed, giant | Sida, prickly | Smartweeds | Sunflower, wild | Velvetleaf | Waterhemp | Corn response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Soil-applied* | | | | | | | | | | | | | | | | |
| Atrazine[a] | 6 | 8 | 9 | 9 | 9 | 8+ | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 7 | 9 | 0 |
| Balance PRO | 7 | 4 | 8 | 8+ | 9+ | 4 | 8+ | 9 | 9 | 6 | 7 | 8 | 6 | 9 | 9 | 2 |
| Callisto | N | 4 | 8 | 6 | 9 | 6 | 9 | 8+ | 7 | 7 | 7 | 8+ | 8 | 9 | 9 | 0 |
| Hornet WDG | N | 8 | 8 | 8+ | 9 | 7 | 7+ | 9 | 8+ | 7+ | 7+ | 8+ | 9 | 8+ | N | 1 |
| Marksman | 6 | 8 | 8 | 7 | 9 | 8 | 8 | 9 | 9 | 7+ | 7 | 9 | 8 | 8 | 9 | 2+ |
| Python[b] | N | 7 | 7+ | 8+ | 8+ | 5 | 7+ | 9 | 7+ | 5 | 8 | 8+ | 7+ | 8 | N | 1 |
| Simazine[a] | 6 | 8 | 9 | 9 | 9 | 8 | 9 | 9 | 9 | 7 | 9 | 9 | 8 | 7 | 8+ | 0 |
| | ..... *See Table 15 for maximum weed sizes* ..... | | | | | | | | | | | | | | | |
| *Postemergence* | | | | | | | | | | | | | | | | |
| **Contact** | | | | | | | | | | | | | | | | |
| Aim | N | 6 | 6 | 8 | 8 | 8 | 8+ | 8+ | 6 | 4 | 7 | 5 | 4 | 9 | 7 | 2 |
| Atrazine[a] + oil | 8 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 8+ | 9 | 9 | 8 | 9 | 1 |
| Buctril | 7 | 9 | 9 | 8+ | 9 | 8 | 9 | 6 | 8+ | 8 | 4 | 8+ | 9 | 8 | 6 | 2 |
| Buctril + atrazine | 8+ | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | 9 | 9 | 8+ | 9 | 2 |
| Laddok S-12 | 6 | 9 | 9 | 8 | 8+ | 8 | 8 | 8+ | 9 | 8+ | 8 | 9 | 9 | 9 | 8+ | 1 |
| Liberty[c] | 7 | 9 | 9 | 8+ | 8 | 8 | 8+ | 8 | 8+ | 8 | 8 | 8+ | 9 | 8 | 8 | 1 |
| Liberty ATZ[c] | 7 | 9 | 9 | 8+ | 9 | 9 | 9 | 9 | 9 | 8+ | 8 | 9 | 9 | 8+ | 9 | 1 |
| Resource | 5 | 7 | 7 | 4 | 7 | 5 | 4 | 7 | 7 | 6 | 7 | 5 | 4 | 9 | 7 | 1+ |
| **Plant-growth regulator (PGR)[d]** | | | | | | | | | | | | | | | | |
| 2,4-D | N | 9 | 7 | 7 | 9 | 9 | 7 | 9 | 9 | 8+ | 8 | 6 | 8 | 8 | 8 | 2+ |
| Banvel or Clarity | 7 | 9 | 8+ | 8+ | 9 | 9 | 8 | 9 | 9 | 9 | 8 | 9 | 8+ | 8 | 9 | 1+ |
| Distinct | 7 | 9 | 8+ | 8+ | 9 | 9 | 8 | 9 | 9 | 9 | 8 | 9 | 9 | 8 | 9 | 2 |
| Marksman | 8 | 9 | 9 | 8+ | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8+ | 9 | 1 |
| Stinger | N | 9 | 8 | N | N | N | 7 | N | 9 | 9 | N | 7 | 9 | N | N | 0 |
| **HPPD inhibitor** | | | | | | | | | | | | | | | | |
| Callisto + atrazine | N | 9 | 9 | 6 | 9 | 7 | 9 | 9 | 8 | 8+ | 6 | 8+ | 8+ | 9 | 9 | 1+ |
| **Acetolactate synthase (ALS)[b]** | | | | | | | | | | | | | | | | |
| Accent | 7+ | 6 | 8 | 7 | 5 | 7 | N | 8+ | 4 | N | N | 8 | 4 | 5 | N | 1+ |
| Basis | N | 7 | 4 | 7 | 8 | 5 | N | 8+ | 5 | N | N | 8 | 8 | 8 | N | 2 |
| Basis Gold | 7 | 8 | 8 | 8 | 8 | 8 | 7 | 9 | 8+ | 7+ | 7 | 9 | 8 | 8 | 7 | 2 |
| Beacon | 8+ | 8 | 8 | 8 | 6 | 6 | 8 | 8+ | 9 | 9 | 7 | 8 | 8+ | 7+ | N | 2 |
| Equip | 8 | 9 | 8+ | 8 | 8+ | 6 | 9 | 9 | 8+ | 8 | 7 | 8 | 9 | 8 | N | 2 |
| Lightning[e] | 6 | 9 | 8+ | 8 | 8+ | 8 | 9 | 9 | 7 | 7 | 8 | 8+ | 9 | 8+ | N | 1+ |
| Option | 7 | 6 | 8 | N | 7+ | 6 | 9 | 8+ | 7 | 6 | N | N | 8 | 8+ | N | 1+ |
| Permit | 5 | 9 | 7 | 7 | 4 | 6 | 4 | 9 | 8+ | 8 | 7 | 7+ | 9 | 8+ | N | 1 |
| Spirit | 8+ | 8+ | 8+ | 8 | 7 | 6 | 8 | 8+ | 9 | 9 | 7 | 8+ | 9 | 8 | N | 1+ |
| Steadfast | N | 6 | 7 | 6 | 6 | 6 | N | 8+ | 5 | N | N | 8 | 7 | 7 | N | 2 |
| Steadfast ATZ | 6 | 8 | 8 | 8 | 9 | 7 | 7+ | 9 | 8+ | 7+ | 6 | 9 | 8 | 8+ | 7 | 2 |

**Table 14. Corn herbicides: Broadleaf weed–control ratings (cont.)**

| Herbicide | Burcucumber | Cocklebur | Jimsonweed | Kochia | Lambsquarters | Morningglories, annual | Nightshade, eastern black | Pigweeds | Ragweed, common | Ragweed, giant | Sida, prickly | Smartweeds | Sunflower, wild | Velvetleaf | Waterhemp | Corn response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ALS + PGR** | | | | | | | | | | | | | | | | |
| Accent Gold | 7 | **9** | 8 | 7 | 7 | 7 | 7 | **9** | **9** | 8+ | 7 | 8+ | **9** | 8+ | N | 2 |
| Celebrity Plus | **8** | 8+ | 8+ | 8+ | 8+ | 8+ | **8** | **9** | 8+ | **8** | 7 | **9** | **8** | 7 | **9** | 1+ |
| Hornet | 5 | **9** | 8 | 7 | 7 | 7 | 7 | 8 | **9** | 8+ | 7 | 8+ | **9** | 8+ | N | 1 |
| NorthStar | 8+ | **9** | 8+ | 8+ | 8+ | **8** | 8+ | **9** | **9** | **9** | 7 | **9** | **9** | 8+ | **8** | 1+ |
| Yukon | 6 | **9** | 8 | 8 | 8+ | 8 | 7+ | **9** | **9** | 8 | 7 | 8 | **9** | 8+ | 8 | 1+ |
| **EPSP** | | | | | | | | | | | | | | | | |
| glyphosate[f,g] | 7+ | **9** | **9** | 8+ | 8+ | 6 | **8** | **9** | **8** | **8** | 7 | **8** | **9** | **8** | **9** | 1 |
| ReadyMaster ATZ[f] | **8** | **9** | **9** | **9** | **9** | 8+ | **9** | **9** | **9** | **8** | **8** | **9** | **9** | **8** | **9** | 1 |

**9** = excellent, **8** = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.
Corn response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.
[a]Will not control triazine-resistant weed biotypes.
[b]Will not control ALS-resistant weed biotypes.
[c]Use only with Liberty Link (glufosinate-resistant) corn hybrids.
[d]Crop response ratings increase if an NIS or a COC is added.
[e]Use only with Clearfield (CL) corn hybrids.
[f]Use only with glyphosate-resistant corn hybrids.
[g]See Table 8 for a listing of glyphosate formulations registered for use on glyphosate-resistant corn hybrids.

*For herbicide ratings for tank mixes or premixes, see the component parts:*

| Premix | Grass | Broadleaf |
|---|---|---|
| Bicep II Magnum | Dual II Magnum | atrazine |
| Bicep Lite II Magnum | Dual II Magnum | atrazine |
| Bullet | Micro-Tech | atrazine |
| Cinch ATZ | Cinch | atrazine |
| Cinch ATZ Lite | Cinch | atrazine |
| Degree Xtra | Degree | atrazine |
| Expert | Dual II Magnum | atrazine + glyphosate |
| FulTime | TopNotch | atrazine |
| G-Max Lite | Outlook | atrazine |
| Guardsman Max | Outlook | atrazine |
| Harness Xtra | Harness | atrazine |
| Keystone | Surpass | atrazine |
| Keystone LA | Surpass | atrazine |
| Lexar | Dual II Magnum | atrazine + Callisto |
| Lumax | Dual II Magnum | atrazine + Callisto |
| Radius | Define | Balance PRO |

**Table 15. Corn "post-broadleaf" herbicides: Maximum broadleaf weed sizes**

| Herbicide (rate) | Burcucumber | Cocklebur, common | Jimsonweed | Kochia | Lambsquarters | Morningglories, annual | Nightshade, eastern black | Pigweeds | Ragweed, common | Ragweed, giant | Smartweeds | Sunflower, wild | Velvetleaf | Waterhemp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Translocated herbicides* | *Maximum size (height) in inches or leaf number (L)* | | | | | | | | | | | | | |
| 2,4-D amine[a] (1 pt) | — | 6 | 3* | 2* | 4 | 6 | 2* | 4 | 6 | 6 | 2* | 2 | 2 | 4 |
| Accent (0.67 oz) | 3 | — | 3 | — | — | 3 | — | 4 | — | — | 4 | — | — | — |
| Accent Gold (3.5 oz) | — | 6 | 6 | — | 2* | — | 2* | 4 | 6 | 6 | 6 | 6 | 6 | — |
| Banvel or Clarity[a] (16 oz) | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 2 | 2 | 4 |
| Basis (0.33 oz) | — | — | — | — | 3 | — | — | 3 | — | — | 3 | 3 | 3 | — |
| Basis Gold (14 oz) | — | 3 | 4 | — | 3 | 3 | 2 | 4 | 3 | 3 | 4 | 6 | 3 | 4 |
| Beacon (0.38 oz) | — | 4 | 4 | — | — | — | 4 | 3 | 6 | 6 | 2 | 6 | — | — |
| Beacon (0.76 oz) | 4 | 4 | 4 | 4 | 1.5* | 1.5* | 4 | 4 | 9 | 9 | 4 | 9 | 4 | — |
| Callisto (3 fl oz) | — | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Celebrity Plus (4.7 oz) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Distinct[a] (4–6 oz) | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 2 | 2 | 4 |
| Equip (1.5 oz) | 4 | 4 | 4 | 3 | 4 | 2 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | — |
| Hornet WDG (3 oz) | — | 6 | 6 | 2* | 2* | 2* | 2* | 2* | 6 | 6 | 6 | 6 | 6 | — |
| Hornet WDG (4 oz) | — | 8 | 8 | 4* | 4* | 4* | 4* | 4* | 8 | 8 | 8 | 8 | 8 | — |
| Lightning[b] (1.28 oz) | — | 8 | 3 | 3 | 3 | 3 | 3 | 8 | 3* | 3 | 3 | 3 | 3 | — |
| Marksman[a] (3.5 pt) | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 8 | 6 | 6 | 6 |
| NorthStar (5 oz) | 4 | 6 | 6 | 4 | 4 | 3* | 6 | 5 | 9 | 9 | 4 | 9 | 4 | 4 |
| Option (1.5 oz) | 3 | 2 | 3 | — | 2 | 3* | 4 | 3 | 2 | 3* | — | 2 | 3 | — |
| Permit (0.67 oz) | 3* | 9 | — | 3 | 2* | — | — | 3 | 9 | 3 | 2 | 12 | 9 | — |
| glyphosate[c,d] (0.75 lb a.e.) | 12 | 24 | 12 | 12 | 12 | 3 | 6 | 18 | 12 | 12 | 6 | 18 | 6 | 6 |
| glyphosate[c,d] (1.13 lb a.e.) | 18 | 36 | 18 | 12 | 20 | 6 | 12 | 24 | 18 | 18 | 9 | 18 | 12 | 12 |
| ReadyMaster ATZ[c] (2.0 qt) | — | 4 | 4 | 4 | 4 | 4 | — | 4 | 4 | 4 | 4 | 4 | 4 | — |
| Spirit (1 oz) | 6 | 8 | 6 | 4 | 3 | 4* | 5 | 4 | 9 | 9 | 6 | 12 | 6 | — |
| Steadfast (0.75 oz) | 4 | 4* | 4 | — | 4* | 4 | — | 4 | — | — | 4* | 4 | 4* | 2* |
| Steadfast ATZ (14 oz) | 4 | 4 | 4 | — | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 4* |
| Stinger (0.5 pt) | — | 5L | 5L | — | — | — | 4L | — | 5L | 5L | — | 5L | — | — |
| Yukon (4 oz) | 12* | 14 | 4 | 6 | 6 | 6 | 6 | 12 | 12 | 6 | 3 | 15 | 12 | 6 |
| *Contact herbicides* | | | | | | | | | | | | | | |
| Aim EW (0.5 fl oz) | — | 4* | 4* | 4* | 3 | 3L | 4 | 4 | 4* | — | 4* | — | 36 | 4* |
| Atrazine[a] 4L (2 qt) | — | 4* | 4 | — | 6 | 4 | 4 | 6 | 4 | 4 | 4 | — | 2* | 4 |
| Basagran 4S (1.5 pt) | — | 6 | 6 | — | — | — | — | — | — | — | 6 | 5 | 2 | — |
| Basagran 4S (2 pt) | — | 10 | 10 | — | 2* | 4* | — | — | 3 | 6 | 10 | 8 | 5 | — |
| Buctril 2E (1 pt) | — | 8 | 4 | — | 6 | 3 | 6 | — | 4 | 4 | 4 | 6 | 3 | 2 |
| Buctril 2E (2 pt) | 4 | 10 | 6 | 2 | 8 | 4 | 6 | 2 | 6 | 6 | 6 | 8 | 5 | 2 |
| Buctril + Atrazine (1.5 pt) | — | 8 | 4 | 2 | 6 | 3 | 4 | 2 | 4 | 6 | 4 | 8 | 3 | 2 |
| Buctril + Atrazine (3.0 pt) | 4 | 12 | 6 | 4 | 12 | 4 | 6 | 4 | 6 | 8 | 8 | 12 | 6 | 6 |
| Laddok S-12 (1.67 pt) | — | 8 | 6 | 4 | 5 | 4 | 1 | 6 | 4 | 4 | 10 | 6 | 5 | 2 |
| Laddok S-12 (2.33 pt) | 3 | 8 | 8 | 4 | 8 | 6 | 1 | 6 | 5 | 6 | 12 | 8 | 8 | 4 |
| Liberty[e] (28 fl oz) | 6 | 6 | 6 | 4 | 4 | 6 | 6 | 4 | 6 | 6 | 6 | 6 | 5 | 4 |
| Liberty[e] (34 fl oz) | 8 | 8 | 8 | 6 | 6 | 7 | 8 | 6 | 8 | 8 | 8 | 8 | 6 | 6 |
| Liberty ATZ[e] (40 fl oz) | 6 | 6 | 6 | 4 | 4 | 6 | 6 | 4 | 6 | 6 | 6 | 6 | 5 | 4 |
| Liberty ATZ[e] (48 fl oz) | 8 | 8 | 8 | 6 | 6 | 7 | 6 | 6 | 8 | 8 | 8 | 8 | 6 | 6 |
| Resource[f] (6 fl oz) | — | — | — | — | 3L* | — | — | 3L | 3L | — | — | — | 6L | — |

**Table 15. Corn "post-broadleaf" herbicides: Maximum broadleaf weed sizes (cont.)**

— = Maximum size not specified on label.
* Suppression or partial control.
[a]No sizes given on label; weed sizes here are best estimates.
[b]Use only with Clearfield (CL) corn hybrids.
[c]Use only with glyphosate-resistant corn hybrids.
[d]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant corn hybrids. Maximum weed heights listed above are from the Roundup Weathermax label. Check individual glyphosate labels for maximum weed heights.
[e]Use only with Liberty Link (glufosinate-resistant) corn hybrids.
[f]The Resource label indicates maximum weed size by leaf number, "L."

**Table 16. Herbicide label statements: Interactions with organophosphate (OP) insecticides**

| Corn herbicide | Soil-applied OP insecticides | | | | | | Foliar OP insecticide,[a] applied | |
|---|---|---|---|---|---|---|---|---|
| | Counter 20CR | | | | Aztec or Fortress | | | |
| | Furrow | T-Band | Thimet | Lorsban | Furrow | Band | Days before | Days after |
| *nicosulfuron and rimsulfuron* | | | | | | | | |
| Accent | No | TCI[b] | TCI | TCI | Yes | Yes | 7 | 3 |
| Accent Gold | No | No | No | TCI | Yes | Yes | 7 | 3 |
| Basis | UCI | UCI | UCI | TCI | TCI | Yes | 7 | 3 |
| Basis Gold | No | TCI | TCI | TCI | Yes | Yes | 7 | 3 |
| Steadfast, Steadfast ATZ | No | UCI[b] | UCI | UCI | Yes | Yes | 7 | 3 |
| Celebrity Plus | No | TCI[b] | TCI | TCI | Yes | Yes | 7 | 3 |
| *primisulfuron and prosulfuron* | | | | | | | | |
| Beacon | No | UCI[b] | TCI | TCI | TCI | TCI | 10 | 7 |
| NorthStar | No | UCI | TCI | TCI | TCI | TCI | 10 | 7 |
| Spirit | No | UCI[b] | TCI | TCI | TCI | TCI | 10 | 7 |
| *flumetsulam* | | | | | | | | |
| Hornet WDG, preemergence | No | No[b] | No | TCI[c] | No[c] | TCI | 10 | 10 |
| Python | No | No[b] | No | TCI[c] | No[c] | TCI | — | — |
| Hornet WDG, postemergence | No | No[b] | No | TCI | TCI | TCI | 10 | 10 |
| *imazethapyr and imazapyr* | | | | | | | | |
| Lightning[d] | Yes | Yes | Yes | TCI | Yes | Yes | — | — |
| Pursuit[d] | Yes | Yes | Yes | TCI | Yes | Yes | — | — |
| *thifensulfuron* | | | | | | | | |
| Harmony GT XP | No | UCI | UCI | TCI | Yes | Yes | 7 | 3 |
| *mesotrione* | | | | | | | | |
| Callisto[e] | No | No | Yes | No | Yes | Yes | 7 | 7 |
| Lexar[e] | No | No | Yes | TCI | Yes | Yes | 7 | 7 |
| Lumax[e] | No | No | Yes | TCI | Yes | Yes | 7 | 7 |
| *halosulfuron* | | | | | | | | |
| Permit | No restrictions on label | | | | | | | |
| Yukon | No restrictions on label | | | | | | | |
| *foramsulfuron and iodosulfuron* | | | | | | | | |
| Equip | No | No | No | TCI | Yes | Yes | 7 | 7 |
| Option | No | No[b] | No | TCI | Yes | Yes | 7 | 7 |

No = Do not use this herbicide on corn if this insecticide was previously applied in this manner.
Yes = This herbicide can be applied to corn if this insecticide was previously applied in this manner.
UCI = Using this herbicide on corn if this insecticide was previously applied in this manner may result in unacceptable crop injury.
TCI = Using this herbicide on corn if this insecticide was previously applied in this manner may result in temporary corn injury.
— = No information is available at this time.
[a]Foliar-applied OPs include Cygon, Diazinon, DiSyston, Imidan, Lorsban, and Malathion.
[b]Counter CR supplemental labeling allows its use in this manner with this herbicide.
[c]Lorsban, Fortress, or Aztec should not be placed in-furrow if a flumetsulam herbicide is to be soil-applied.
[d]Use only Clearfield (CL) corn hybrids.
[e]Postemergence applications.

**Table 17. Corn "post" herbicides: Adjuvant use plus application and use restrictions**

| Herbicide | Adjuvant and nitrogen | Rain-free period (hr) | Reentry interval (hr) | PHI (days) | Apply broadcast up to | Use drop nozzles |
|---|---|---|---|---|---|---|
| 2,4-D amine | None | 6–8 | 48 | 7 | 8" | 8"" to tassel |
| 2,4-D ester | None | 1–2 | 12 | 7 | 8" | 8" to tassel |
| Accent | COC or NIS + $NH_4$ | 4 | 4 | 30 | 20"/V6 | 20"to 36"/V10 |
| Accent Gold | COC + $NH_4$ | 6 | 48 | 85 | 12"/V6 | |
| Aim EW | NIS or COC[a] + $NH_4$ | 1 | 12 | — | 8-leaf/V8 | V8 to V14 |
| Atrazine | COC | 1–2 | 12 | 21 | 12" | |
| Banvel | NIS[a] or $NH_4$[a] | 4 | 24 | — | 24"[b] to 36" | Reduces drift |
| Basagran | COC + $NH_4$ | 4 | 12 | 12 | Any size? | |
| Basis | NIS or COC + $NH_4$ | 4 | 4 | 30 | 6"/V2 | |
| Basis Gold | COC + $NH_4$ | 4 | 12 | 30 | 12"/V6 | |
| Beacon | COC or NIS + $NH_4$ | 4 | 12 | 45 | 4" to 20" | Splits 20" to tassel |
| Buctril | COC[d] or NIS[d] | 1 | 12 | 45 | pretassel | |
| Buctril + atrazine | COC[d] or NIS[d] | 1 | 12 | 45 | 12" | |
| Callisto | COC + $NH_4$ | 1 | 12 | 45 | 30"/8-leaf | |
| Celebrity Plus | NIS + $NH_4$ | 4 | 12 | 72/32 | 4" to 20"/V6 | 20" to 24" |
| Clarity | $NH_4$ + COC[a, e] or NIS[a] | 4 | 12 | — | 24"[b] to 36" | Reduces drift |
| Distinct | NIS + $NH_4$ | 4 | 12 | 72/32 | 4" to 24" | 24" to 36" |
| Equip | MSO + $NH_4$ | 2 | 12 | 70/45 | V4 | V4 to V8 |
| Harmony GT XP | COC or NIS + $NH_4$ | 1 | 4 | 30 | 12""/V5 | |
| Hornet WDG | NIS, MSO, or COC, ± $NH_4$ if dry | 2 | 48 | 85 | 20"/V6 | 20" to 36" |
| Laddok S-12 | COC + $NH_4$ | 4[c] | 12 | 21 | 12" | |
| Liberty[f] | AMS only | 4 | 12 | 70/60 | 24"/V7 | 24" to 36" |
| Liberty ATZ[f] | AMS only | 4 | 12 | 70/60 | 12" | |
| Lightning[g] | NIS + $NH_4$ | 1 | 12 | 45 | 20"/V6 | 20" to PHI |
| Marksman | NIS or $NH_4$ | 4 | 48 | — | 5-leaf or 8" | |
| NorthStar | COC[h] or NIS + $NH_4$ | 4 | 12 | 60/45 | 4" to 20"/V6 | 20" to 36"[b] |
| Option | MSO + $NH_4$ | 2 | 12 | 70/45 | V6 | V6 to V8 |
| Permit | COC or NIS + $NH_4$ | 4 | 12 | 30 | layby (36") | |
| Pursuit[g] | COC or NIS + $NH_4$ | 1 | 12 | 45 | See PHI. | |
| Resource | COC + $NH_4$ | 1 | 12 | 28 | 2- to 10-leaf | |
| glyphosate[i, j] | See label[k] (AMS optional) | 1–2 | 4 | 7/50 | 30"/V8 | 30" to 48"[l] |
| ReadyMaster ATZ[f] | AMS optional | 2[c] | 12 | 50 | 12" | |
| Sencor | NIS or $NH_4$ | — | 12 | 60 | pretassel | See tank-mix partner |
| Shotgun | None | 4 | 12 | 21 | 8"/4-leaf | 8" to 12" |
| Spirit | COC or NIS + $NH_4$ | 4 | 12 | 60/40 | 4" to 20"/V6 | 20" to 24"/< tassel |
| Steadfast | COC or NIS + $NH_4$ | 4 | 4 | 30 | 20"/V6 | |
| Steadfast ATZ | COC or NIS + $NH_4$ | 4 | 12 | 60 | 12"/V6 | |
| Stinger | NIS optional | 6 | 12 | 40 | 24" | |
| Yukon | NIS or COC, ± $NH_4$ | 4 | 12 | 30 | 24" to 36"[b] | Reduces drift |
| *Harvest-aid use* | | | | | | |
| 2,4-D | None | 6–8 | 48 | — | After dent | |
| glyphosate | See label[k] (AMS optional) | 1–2 | 4 | 7 | After black layer | |
| Gramoxone Max | NIS | ½ | 24 | 7 | After black layer | |

COC = crop-oil concentrate, NIS = nonionic surfactant, $NH_4$ = ammonium fertilizer adjuvant (UAN or AMS), UAN = urea–ammonium nitrate (28-0-0), AMS = ammonium sulfate (spray grade 21-0-0), PHI = preharvest interval for grain harvest, shorter for silage, — = no information is available at this time.

**Table 17. Corn "post" herbicides: Adjuvant use plus application and use restrictions (cont.)**

[a] Allowed if arid or droughty conditions exist at application.
[b] Up to 24 inches if nearby soybeans are more than 10 inches tall or are blooming.
[c] Current label indicates rainfall soon after application may decrease the effectiveness.
[d] Adjuvants allowed if injury is acceptable.
[e] Use of oils (penetrants) may cause injury "if corn is > 5 inches tall."
[f] Use only with Liberty Link (glufosinate-resistant) corn hybrids.
[g] Use only with Clearfield (CL) corn hybrids.
[h] COC allowed only up to 12-inch-tall corn.
[i] Use only with glyphosate-resistant corn hybrids.
[j] Table 8 lists glyphosate formulations registered for use on glyphosate-resistant corn hybrids. Consult individual glyphosate labels for information on other glyphosate formulations.
[k] Some glyphosate formulations contain surfactants. Consult individual glyphosate labels for adjuvant use.
[l] POST-directed applications in glyphosate-resistant hybrids are labeled only for certain hybrids.

**Table 18. Soybean herbicides: Preplant or preemergence rates per acre**

| Herbicide | Unit | 1% OM sandy loam[a] | 1–2% OM silt loam[b] | 3–4% OM silty clay loam[c] | 5–6% OM silty clay[c] |
|---|---|---|---|---|---|
| Backdraft SL 1.35L | qt | 2.5 | 2.5 | 2.5 | 2.5 |
| Boundary 6.5EC | pt | No | 1.8–2.1 | 2.4–2.7 | 2.4–3.0 |
| Canopy EX 29.5WDG | oz | 1.1–3.3 | 1.1–3.3 | 1.1–3.3 | 1.1–3.3 |
| Command 3ME | pt | 2.00 | 2.00 | 2.67 | 2.67 |
| Define 4SC | fl oz | 8–10 | 10–12 | 10–14 | 10–14 |
| Dual II Magnum 7.64EC | pt | 1.0 | 1.33 | 1.67 | 2.0 |
| Extreme 2.17L | pt | 3.0 | 3.0 | 3.0 | 3.0 |
| FirstRate 84WDG | oz | 0.6 | 0.6 | 0.75 | 0.75 |
| IntRRo 4EC | qt | 2.0 | 2.25 | 2.75 | 3.0 |
| Micro-Tech 4ME | qt | 2.0 | 2.25 | 2.75 | 3.0 |
| Outlook 6EC | fl oz | 12–14 | 14–16 | 18–21 | 18–21 |
| Partner 65DF | lb | 3.0 | 3.5 | 4.0 | 4.5 |
| Pendimax or Prowl 3.3EC | pt | 1.5 | 2.0 | 3.6 | 3.6 |
| Prowl $H_2O$ 3.8CS | pt | 1.5 | 2.5 | 3.0 | 3.0 |
| Pursuit 2AS | fl oz | 4.0 | 4.0 | 4.0 | 4.0 |
| Pursuit 70DG | oz | 1.44 | 1.44 | 1.44 | 1.44 |
| Pursuit Plus 2.9EC | pt | 2.5 | 2.5 | 2.5 | 2.5 |
| Python 80WDG | oz | 0.80 | 1.00 | 1.25 | 1.33 |
| Scepter 70DG | oz | 2.8 | 2.8 | 2.8[e,f] | 2.8[e,f] |
| Sencor 75DF | lb | No[d] | 0.50 | 0.75 | 1.00 |
| Sequence 5.25L | pt | 2.5–3.5 | 3.5–4.0 | 4 | 4 |
| Treflan 4EC | pt | 1.0 | 1.5 | 2.0 | 2.0 |
| Valor SX 51WDG | oz | 2.0–2.5 | 2.0–2.5 | 2.5 | 3.0 |

OM = percent organic matter in the soil.
[a] Characteristic of most sandy soils in Illinois.
[b] Characteristic of many Illinois soils south of Interstate 70.
[c] Characteristic of "prairie soils" in northern Illinois.
[d] May cause excess crop injury on these soils.
[e] Carryover injury to corn may occur on these soils unless Clearfield (CL) corn hybrids are planted.
[f] May not be suitable on these soils.

**Table 19. Soybean herbicides (soil- or foliar-applied): Grass and nutsedge control ratings**

| | Annuals | | | | | | | | Perennials | | | | Volunteer crops | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Herbicide | Barnyardgrass | Crabgrass | Cupgrass, woolly | Foxtail, giant | Foxtail, yellow | Panicum, fall | Sandbur | Shattercane | Johnsongrass | Muhly, wirestem | Nutsedge, yellow | Quackgrass | Cereals, volunteer (wheat, oats, rye) | Corn, volunteer | Soybean response |
| *Soil-applied* | | | | | | | | | | | | | | | |
| Define* | 8+ | 8 | 6 | 8 | 8 | 8 | 5 | 4 | N | N | 4 | N | N | N | 1 |
| Dual II Magnum | 9 | 9 | 7 | 9 | 9 | 9 | 6 | 5 | N | N | 8 | N | N | N | 1 |
| Outlook | 9 | 9 | 7 | 9 | 9 | 8+ | 6 | 5 | N | N | 7+ | N | N | N | 1 |
| IntRRo | 9 | 9 | 7 | 9 | 9 | 9 | 6 | 5 | N | N | 7+ | N | N | N | 1 |
| Command 3ME | 9 | 8+ | 7 | 9 | 8+ | 9 | 7 | 7 | N | N | N | N | 9 | 5 | 1 |
| Pendimax/ Prowl | 9 | 9 | 8+ | 9 | 9 | 9 | 8 | 7+ | N | N | N | N | 6 | 5 | 1+ |
| Trifluralin | 9 | 9 | 8+ | 9 | 9 | 9 | 8+ | 8 | N | N | N | N | 6 | 6 | 1+ |
| | ..... *See Table 20 for maximum grass sizes* ..... | | | | | | | | | | | | | | |
| *Postemergence* | | | | | | | | | | | | | | | |
| Assure II | 8+ | 8+ | 8 | 9 | 7 | 9 | 9 | 9 | 9 | 7 | N | 8+ | 9 | 9 | 0 |
| Backdraft[a] | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8+ | 7 | 9 | 9 | 9 | 1+ |
| Extreme[a] | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8+ | 7 | 9 | 9 | 9 | 1+ |
| Fusilade DX | 8+ | 8 | 8 | 8+ | 8 | 8+ | 8+ | 9 | 9 | 8+ | N | 8+ | 9 | 9 | 0 |
| Fusion | 9 | 8+ | 8 | 9 | 9 | 9 | 8+ | 9 | 9 | 7 | N | 7 | 9 | 9 | 0 |
| Poast Plus | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8+ | 7+ | 7 | N | 7 | 7 | 8 | 0 |
| Select | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8 | N | 8 | 7 | 9 | 0 |
| Pursuit | 7 | 7 | 5 | 8 | 7 | 7 | 6 | 8+ | 5 | N | 5 | N | 5 | 5 | 1+ |
| Raptor | 8 | 7 | 5 | 8+ | 8 | 8 | 7 | 9 | 6 | N | 5 | N | 6 | 7 | 2 |
| glyphosate[a,b] | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 8+ | 7 | 9 | 9 | 9 | 0 |
| Basagran | N | N | N | N | N | N | N | N | N | N | 8 | N | N | N | 1 |
| Classic | N | N | N | N | N | N | N | N | N | N | 8 | N | N | 6 | 1+ |

9 = excellent, 8 = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

Soybean response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.

*Expect only early season weed control on medium and fine textured soils.

[a]Use only with glyphosate-resistant soybean varieties.

[b]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant soybean varieties.

**Table 20. Soybean "post-grass" herbicides: Maximum grass sizes**

| | | Annuals | | | | | | | | | | | Perennials[a] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Herbicide | fl oz/A | Barnyardgrass | Corn[d], volunteer | Crabgrass | Cupgrass, woolly | Foxtail, giant | Foxtail, yellow | Panicum, fall | Sandbur | Shattercane | Signalgrass, broadleaf | Wheat, volunteer | Johnsongrass, seedling | Johnsongrass, rhizome | Quackgrass | Muhly, wirestem |
| | | *Maximum grass size in inches for given rate.* | | | | | | | | | | | | | | |
| Assure II | 5 | — | 18 | — | — | 4 | — | — | — | 12 | — | — | 8 | — | — | — |
| | 7–9[b] | 6[c] | — | 6[c] | 4[c] | 8 | 4[c] | 6 | 6 | — | 6[c] | 6 | — | — | — | 8 |
| | 10 | — | — | — | — | — | — | — | — | — | — | — | — | 24 | 10 | — |
| Fusion | 6–8[b] | — | 24 | — | — | 8 | 4 | — | — | 12 | — | — | 8 | — | — | — |
| | 8–10[b] | 4 | — | 4 | 4 | 8 | 4 | 6 | 4 | — | 4 | 6 | — | 12[2] | 10[2] | — |
| | 10–12[b] | — | — | — | — | — | — | — | — | — | — | — | — | 18[1] | 10[1] | 12 |
| Fusilade DX | 6–8 | — | 24 | — | — | — | — | — | — | 12 | — | 6 | 8 | 12[2] | 10[2] | — |
| | 10–12[b] | 3 | — | 2 | 4 | 6 | 4 | 6 | 4 | — | 4 | — | — | 18[1] | 10[1] | 12 |
| Poast Plus | 12 | 4 | 12 | — | — | 4 | — | 4 | — | — | — | — | — | — | — | — |
| | 24–30 | 8 | 20 | 6 | 8 | 8 | 8 | 8 | 3 | 18 | 8 | — | 8 | 12[2] | 8[2] | — |
| | 36 | 12 | — | 8 | — | 16 | 16 | 12 | — | — | 12 | 4 | — | 25[1] | 8[1] | 6 |
| Pursuit | 4 | 3* | — | 3* | 3* | 6 | 3 | * | — | 8* | 8* | — | 8 | 12* | — | — |
| Raptor | 5 | 5* | 8 | 4* | 4* | 6 | 6 | 6 | — | 8 | 5 | 4 | 8 | 12* | 8* | — |
| Select | 4–5 | 4 | 12 | 4 | — | 4 | — | 4 | — | 10 | 4 | — | 6 | — | — | — |
| | 6–8 | 8 | 24 | 6 | 8 | 12 | 8 | 8 | 6 | 18 | 6 | 6 | 10 | 18[2] | — | — |
| | 8–16 | — | — | — | — | — | — | — | — | — | — | — | — | 24[1] | 12 | 8 |
| **Herbicides requiring glyphosate-resistant soybean varieties** | | | | | | | | | | | | | | | | |
| | | *Maximum grass size in inches for given rate.* | | | | | | | | | | | | | | |
| glyphosate[e] | 0.56 lb a.e. | 3 | 12 | 6 | 6 | 12 | 12 | 4 | 12 | 12 | 3 | 6 | 12 | 12 | 8 | >8 |
| | 0.75 lb a.e. | 6 | 20 | 12 | 12 | 20 | 20 | 12 | 12 | 20 | 6 | 12 | 18 | 12 | 8 | >8 |
| | 1.13 lb a.e. | 9 | 20 | 12 | 12 | 20 | 20 | 12 | 12 | 20 | 9 | 18 | 24 | 12 | 8 | >8 |
| Backdraft SL | 2.5 qt | 5 | 20 | 18 | 12 | 12 | 12 | 6 | — | 18 | 5 | 12 | 18 | — | — | — |
| Extreme | 3.0 pt | 6 | — | 12 | 12 | 18 | 18 | 12 | — | 18 | 8 | 18 | 12 | 12 | — | — |

— = Maximum size not specified on label.
*Suppression or partial control.
[a]Perennials usually require sequential applications for satisfactory control. See the label for more information.
[b]Use higher rate if tank-mixed with broadleaf herbicide, if the weather is dry, or if weeds have reached maximum size.
[c]For best results on these grasses, do not tank-mix with a broadleaf herbicide.
[d]Volunteer corn that is not resistant to the herbicide.
[e]Table 8 lists glyphosate formulations registered for use in glyphosate-resistant soybeans. Maximum weed heights listed above are from the Roundup Weathermax label. Check individual glyphosate labels for maximum weed heights.
[1]Only one application is required.
[2]Two applications are required.

**Table 21. Soil-applied soybean herbicides: Broadleaf weed–control ratings**

| Herbicide | Burcucumber | Cocklebur, common | Jimsonweed | Kochia | Lambsquarters | Morningglories, annual | Nightshade, eastern black | Pigweeds | Ragweed, common | Ragweed, giant | Sida, prickly | Smartweeds | Sunflower, wild | Velvetleaf | Waterhemp | Soybean response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Soil-applied "grass"* | | | | | | | | | | | | | | | | |
| Define* | N | N | 4 | N | 5 | N | 5 | 6 | 4 | N | N | N | N | N | 6 | 1 |
| **Dual II Magnum** | N | N | 4 | N | 6 | N | 8 | 8 | 5 | N | N | N | N | N | 7+ | 1 |
| Outlook | N | N | 4 | N | 6 | N | 8 | 8 | 5 | N | N | N | N | N | 7+ | 1 |
| **IntRRo** | N | N | 4 | N | 6 | N | 8 | 8+ | 5 | N | N | N | N | N | 7+ | 1 |
| Pendimax / Prowl | N | N | N | 7+ | 8 | N | N | 8+ | N | N | N | 4 | N | 6 | 8 | 1+ |
| **Trifluralin** | N | N | N | 7+ | 8+ | N | N | 8+ | N | N | N | 4 | N | N | 8 | 1+ |
| *Soil-applied "broadleaf"* | | | | | | | | | | | | | | | | |
| Command | N | 6 | 8 | 9 | 8+ | N | 5 | 5 | 8 | 5 | 8+ | 8 | 4 | 9 | 5 | 1 |
| **Sencor**[a] | N | 6 | 7+ | 8 | 9 | N | N | 9 | 8+ | 5 | 8 | 9 | 6 | 8 | 8 | 2 |
| Canopy EX[b] | 7 | 8+ | 7+ | 8 | 9 | 7+ | N | 9 | 8+ | 7+ | 7 | 9 | 7+ | 8 | N | 1 |
| **Python**[b] | N | 7 | 8 | 8+ | 8+ | 6 | 7+ | 9 | 7+ | 5 | 8 | 8 | 7 | 8+ | N | 1 |
| FirstRate, Amplify[b] | — | 8+ | 8+ | 8 | 8+ | 8 | 4 | 8+ | 9 | 8 | 7 | 8 | 9 | 8 | N | 1 |
| **Pursuit**[b] | 5 | 7 | 7 | 8 | 8 | 7 | 9 | 9 | 7 | 6 | 8 | 8+ | 8 | 8 | N | 1 |
| Scepter[b] | 7 | 9 | 8 | 5 | 9 | 7 | 8 | 8+ | 8+ | 8 | 8+ | 8+ | 9 | 7 | N | 1 |
| **Valor SX** | N | 4 | 7+ | 7+ | 8+ | 7 | 8+ | 8+ | 8 | 4 | 8 | 7 | N | 7+ | 8+ | 1+ |

9 = excellent, 8 = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled, — = no information is available at this time. Boldface indicates acceptable control.
Soybean response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.
*Expect only early season weed control on medum and fine textured soils.
[a]Will not control triazine-resistant weed biotypes.
[b]Will not control ALS-resistant weed biotypes.

For herbicide ratings for tank mixes or premixes, see the component parts:

| Premix | Grass | Broadleaf |
|---|---|---|
| Boundary | Dual Magnum | Sencor |
| Backdraft | glyphosate | Scepter |
| Extreme | glyphosate | Pursuit |
| Gangster | — | Valor + FirstRate |
| Pursuit Plus | Prowl | Pursuit |
| Sequence | Dual Magnum | glyphosate |

**Table 22. "Post-broadleaf" soybean herbicides: Weed-control ratings**

| Herbicide | Burcucumber | Cocklebur, common | Jimsonweed | Kochia | Lambsquarters | Morningglories, annual | Nightshade, eastern black | Pigweeds | Ragweed, common | Ragweed, giant | Sida, prickly | Smartweeds | Sunflower, wild | Velvetleaf | Waterhemp | Soybean response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Contact-postemergence* | ····· *See Table 23 for maximum weed sizes* ····· | | | | | | | | | | | | | | | |
| Basagran | N | **9** | **9** | 7 | 7 | 5 | N | N | 7 | 7 | **8** | **9** | **8+** | **8+** | N | 1 |
| Storm | 6 | **8+** | **9** | 6 | 6 | 7 | 7 | **9** | **8+** | 7+ | 7 | **9** | 7 | 7 | **8+** | 2 |
| Ultra Blazer | 7 | 7 | **9** | 6 | 5 | **8** | **8+** | **9** | **8+** | **8** | N | **8+** | 6 | 6 | **8** | 2 |
| Cobra | 7 | **8+** | **9** | 7 | 6 | 7+ | **8+** | **9** | **9** | **8+** | 6 | 5 | **8** | 7 | **8+** | 2+ |
| Phoenix | 6 | **8** | **8+** | 6 | 5 | 6 | **8** | **8+** | **8+** | **8** | 5 | 5 | 7 | 6 | **8** | 1+ |
| Reflex | 6 | 7 | **8+** | 5 | 5 | **8** | **8** | **9** | **8** | **8** | N | 7+ | 7 | 6 | 7+ | 1+ |
| Flexstar | 7 | **8** | **9** | 6 | 6 | **8** | **8** | **9** | **8+** | **8+** | N | **8** | 7 | **8** | **8** | 2 |
| Resource | 5 | 7 | 7 | 4 | 7 | 5 | 5 | 7 | 7 | 6 | 7 | 5 | 4 | **9** | 7 | 1+ |
| *Systemic-postemergence* | ····· *See Table 23 for maximum weed sizes* ····· | | | | | | | | | | | | | | | |
| **Acetolactate synthase (ALS)**[a] | | | | | | | | | | | | | | | | |
| Classic | **8** | **9** | **8+** | 4 | 4 | 7 | N | **8+** | **8** | 7 | N | **8** | **9** | **8** | N | 1+ |
| Harmony GT XP | N | 6 | 6 | 5 | **8+** | 4 | N | **9** | 5 | 4 | N | **8+** | 6 | **8** | N | 2+ |
| Synchrony XP[b] | **8** | **9** | **8+** | 6 | **8+** | 7+ | N | **9** | **8** | 7+ | N | **9** | **9** | **8+** | N | 1 |
| FirstRate, Amplify | 6 | **9** | **9** | 5 | N | **8** | N | 5 | **9** | **9** | 4 | **8+** | **9** | **8+** | N | 1 |
| Pursuit | 5 | **8+** | **8** | **8** | 6 | 7 | **8+** | **9** | 7 | 7 | 6 | **8+** | **8** | **8+** | N | 1+ |
| Raptor | 6 | **8+** | **8** | **8+** | **8** | 7+ | **9** | **9** | 7 | **8** | 6 | **8+** | **9** | **8+** | N | 2 |
| Scepter | N | **9** | 4 | 4 | N | N | 5 | **9** | 5 | N | N | 6 | **8** | N | N | 1 |
| **EPSP** | | | | | | | | | | | | | | | | |
| glyphosate[c,d] | **8** | **9** | **9** | **8+** | **8+** | 7 | **8** | **9** | **8** | **8+** | 7 | **8** | **9** | **8** | **9** | 0 |
| **ALS + EPSP** | | | | | | | | | | | | | | | | |
| Backdraft SL[c] | **8** | **9** | **9** | **8+** | **8+** | 7 | **8** | **9** | **8** | **8+** | 7 | **8** | **9** | **8** | **9** | 1+ |
| Extreme[c] | **8** | **9** | **9** | **8+** | **8+** | 7 | **9** | **9** | **8** | **8+** | 7 | **8+** | **9** | **8+** | **8+** | 1+ |

**9** = excellent, **8** = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

Soybean response: 0 = minimal, 1 = possible, 2 = probable, 3 = serious.

[a]Will not control ALS-resistant weed biotypes.

[b]Use only with STS-designated soybean varieties or at 0.375 oz/A on non-STS soybeans.

[c]Use only with glyphosate-resistant soybean varieties.

[d]See Table 8 for a listing of glyphosate formulations registered for use on glyphosate-resistant soybean varieties.

**Table 23. Soybean "post-broadleaf" herbicides: Maximum weed sizes and application rates**

| Herbicide | Rate | Burcucumber | Cocklebur, common | Jimsonweed | Kochia | Lambsquarters[a] | Morningglories, annual | Nightshade, eastern black | Pigweeds | Ragweed, common | Ragweed, giant | Sida, prickly | Smartweeds | Sunflower, wild | Velvetleaf | Waterhemp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *ALS translocated*[b] | *oz/A* | *Label weed height in inches* | | | | | | | | | | | | | | |
| Classic 25DF | 0.50 | — | 6 | 4 | — | — | 2[c] | — | 2 | — | — | — | 2 | 5 | — | — |
| Classic 25DF | 0.75 | 6[c] | 12 | 6 | — | — | 4[c] | — | 4 | 4 | 6 | — | 4 | 8 | 6 | — |
| FirstRate 84WDG | 0.30 | 6[c] | 10 | 4 | — | — | 4 | — | — | 8 | 10 | — | 6 | 12 | 6 | — |
| Harmony GT XP 75DF | 0.083 | — | 6[c] | 4[c] | — | 4 | — | — | 8 | — | — | — | 6 | 6[c] | 6 | — |
| Pursuit 70DG | 1.44 | — | 8 | 3 | 3 | 2[c] | 2 | 3 | 8 | 3[c] | 3[c] | — | 3 | 3 | 3 | — |
| Raptor 1S | 4–5 | — | 8 | 6 | 4 | 5 | 4 | 5 | 8 | 5[c] | 5[c] | 4[c] | 5 | 8 | 8 | — |
| Scepter 70DF | 1.40 | — | 8 | — | — | — | — | — | 4 | — | — | — | — | 4 | — | — |
| Synchrony XP | 0.50 | 3 | 8 | 5 | 3[c] | 4 | 3[c] | — | 8 | 4 | 4[c] | — | 8 | 8 | 8 | — |
| *Other translocated* | | | | | | | | | | | | | | | | |
| Backdraft SL (RR) | 2.5 qt | 6 | 18 | 3 | — | 8 | 6 | 10 | 6 | 6 | 4 | 2 | 6 | 18 | 5 | 6 |
| Extreme (RR) | 3.0 pt | 6 | 18 | 5 | 12 | 8 | 2 | 12 | 18 | 6 | 6 | — | 6 | 18 | 5 | 12 |
| glyphosate[d] (RR) | 0.75 lb a.e. | 12 | 24 | 12 | 12 | 12 | 3 | 6 | 18 | 12 | 4 | — | 6 | 18 | 6 | 6 |
| glyphosate[d] (RR) | 1.13 lb a.e. | 18 | 36 | 18 | 12 | 20 | 6 | 12 | 24 | 18 | 6 | — | 9 | 18 | 12 | 12 |
| *Contact* | *pt/A* | *Label weed height in inches* | | | | | | | | | | | | | | |
| Basagran | 1.0 | — | 4 | 4 | — | 1[c] | — | — | — | — | — | — | 4 | 3 | 2 | — |
| Basagran | 2.0 | — | 10 | 10 | — | 2[c] | 4[c] | — | — | 3 | 6 | 4 | 10 | 8 | 6 | — |
| Ultra Blazer | 1.0 | — | — | 4 | — | — | 2 | < 2 | < 4 | 2 | < 2 | — | 4 | — | — | < 4 |
| Ultra Blazer | 1.5 | — | 2[c] | 6 | — | 2[c] | 4 | 2 | 4 | 3 | 3 | — | 6 | — | — | 4 |
| Storm | 1.5 | — | 6 | 6 | — | 2[c] | 2 | 2 | 3 | 3 | 6 | 2 | 6 | — | 2 | 3 |
| *Contact* | *pt/A* | *Label weed height in inches* | | | | | | | | | | | | | | |
| Cobra | 0.5 | — | 4L | 4L | — | — | — | 4L | 6L | 6L | 4L | — | — | — | — | 5L |
| Cobra | 0.78 | 4L | 6L | 4L | 8L | — | 2–4L[e] | 6L | 6L | 8L | 6L | 4L | 4Lc | 2L | 4L | 6L |
| Phoenix | 0.5 | — | — | 2 | — | — | — | 2 | 3 | 4 | 3 | — | — | — | — | 4 |
| Phoenix | 0.78 | — | 2 | 4 | — | — | — | 3 | 4 | 6 | 4 | 2 | — | — | — | 6 |
| Flexstar | 1.25 | — | 6L | 8L | — | 2L[c] | 3–4L[e] | 6L | 6L | 6L | 6L | 2L | 6L | 2L | 4L | 4L |
| Reflex | 1.25 | — | 2L | 6L | — | 2L[c] | 2–4L[e] | 4L | 4L | 4L | 4L | — | 4L | — | 2L | 2L |
| Resource | 0.38 | — | — | — | — | 3L[c] | — | — | 3L | 4L | — | 3L | — | — | 8L | — |
| Resource | 0.50 | — | 3L[c] | 4L | — | 3L[c] | — | — | 4L | 6L | — | 4L | — | — | 10L | — |

— = No information is available at this time.
[a]Lambsquarters control is erratic with many herbicides.
[b]ALS-resistant biotypes are not controlled by ALS herbicides.
[c]Suppression or partial control only; may need supplemental control, as with split applications.
[d]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant soybean varieties. Maximum weed heights listed above are from the Roundup Weathermax label. Check individual labels for maximum weed heights.
[e]Size varies with morningglory species.

**Table 24. Soybean "post" herbicides: Adjuvant use plus application and use restrictions**

| Herbicide | Adjuvants and nitrogen | Rain-free period (hr) | Reentry interval (hr) | Preharvest interval (days) | Feed/graze forage |
|---|---|---|---|---|---|
| *No-till burndown* | | | | | |
| 2,4-D amine | None | 6–8 | 48 | NA | No |
| 2,4-D ester | None | 1–2 | 12 | NA | No |
| Gramoxone Max | COC or NIS | 0.5 | 12 | NA | NA |
| glyphosate | AMS optional | 0–2 | 4–12 | NA | NA |
| *Postemergence grass only*[c] | | | | | |
| Assure II | COC or NIS; $NH_4$ optional | 1 | 12 | 80 | No |
| Fusilade DX | COC or NIS; $NH_4$ optional | 1 | 12 | Prebloom | No |
| Fusion | COC or NIS; $NH_4$ optional | 1 | 24 | Prebloom | No |
| Poast Plus | COC; $NH_4$ optional | 1 | 12 | 75 | Hay? |
| Select or Select Max | COC; $NH_4$ optional | 1 | 24 | 60 | No |
| *Postemergence broadleaf, contact* | | | | | |
| Basagran | COC; $NH_4$ optional | 4 | 48 | 30 | Yes/30 days |
| Cobra | COC or NIS; check humidity | 0.5 | 12 | 45 | No |
| Phoenix | NIS or COC | 2 | 12 | 45 | No |
| Flexstar | MSO or COC + $NH_4$ | 1 | 24 | Prebloom | No |
| Resource | MSO or COC; $NH_4$ optional | 1 | 12 | 60 | No |
| Storm | COC or NIS or $NH_4$ | 4 | 48 | 50 | No |
| Ultra Blazer | COC, NIS, or $NH_4$ | 4 | 48 | 50 | No |
| *Postemergence broadleaf, systemic*[c] | | | | | |
| Classic | NIS, COC, or MSO[b] + $NH_4$ | 1 | 12 | 60 | No |
| FirstRate | NIS, COC, or MSO + $NH_4$ | 2 | 12 | 65 | Yes/14 days |
| Harmony GT XP | NIS or COC[a,b] + $NH_4$ | 1 | 4 | 60 | No |
| Pursuit | MSO, COC, or NIS + $NH_4$ | 1 | 12 | 85 | No |
| Raptor | MSO, COC, or NIS + $NH_4$ | 1 | 4 | 85 | No |
| Synchrony XP | COC; $NH_4$ optional | 1 | 12 | 60 | No |
| glyphosate[d, e] | See label (AMS optional)[f] | 1–2 | 4 | 14 | Yes/PHI |
| Backdraft SL[d] | NIS + $NH_4$[g] | 1 | 12 | 90 | No |
| Extreme[d] | NIS + $NH_4$[g] | 1 | 48 | 85 | No |
| *Harvest-aid use* | | | | | |
| Clarity | $NH_4$ + COC or NIS | 4 | 12 | 14 | No |
| Gramoxone Max | NIS or COC | 0.5 | 24 | 15 | No |
| glyphosate[e] | See label (AMS optional)[f] | 1–2 | 12 | 7 | > 25 days |

COC = crop-oil concentrate, MSO = methylated seed oil (specialized VOC), NIS = nonionic surfactant, $NH_4$ = ammonium fertilizer adjuvant = UAN or AMS; UAN = urea–ammonium nitrate (28-0-0), AMS = ammonium sulfate (spray grade 21-0-0); PHI = preharvest interval.

[a]Use only if droughty conditions exist at application.

[b]Penetrant adjuvant allowed but reduces crop tolerance.

[c]Some tank mixes allow NIS or COC; see the tank-mix partner's label.

[d]Use only with glyphosate-resistant soybean varieties.

[e]Table 8 lists glyphosate formulations registered for use on glyphosate-resistant soybean varieties. Consult individual glyphosate labels for information on other glyphosate formulations.

[f]Some glyphosate formulations contain surfactants. Consult individual glyphosate labels for adjuvant use.

[g]Spray-grade AMS is the preferred nitrogen source.

**Table 25. Corn "post" herbicides: Perennial broadleaf weed–control ratings**

| Herbicide | Corn stage | Rate per acre | Artichoke, Jerusalem | Bindweed, field or hedge | Dogbane, hemp | Horsenettle | Milkweed, common | Milkweed, honeyvine (climbing) | Morningglory, bigroot (wild sweet potato) | Pokeweed | Smartweed, swamp (devil's shoestring) | Thistle, Canada |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2,4-D amine | 8 in. to tassel[a] | 1 pt | 7 | 7 | 6 | 6 | 5 | 6 | 6 | 7 | N | 6 |
| **2,4-D ester** | **Preharvest** | **2 pt** | **8** | **8** | **6** | **7** | **7** | **7** | **7** | **8** | **6** | **7** |
| Banvel, Clarity | 8–36 in.[a] | 0.5 pt | **8** | **8** | 5 | 7 | 6 | 6 | 5 | 7 | 7 | **8** |
| **Distinct** | **10–24 in.** | **4 oz** | **9** | **9** | 6 | 7 | 7 | 7 | 6 | **8** | **8** | **8** |
| Stinger | ≤ 24 in. | 0.5–0.67 pt | **9** | 4 | 4 | 5 | 5 | 6 | 4 | 4 | 5 | **9** |
| **Hornet WDG** | **≤ 20 in.** | **3.0 to 5.0 oz** | **8** | **4** | **4** | 5 | **4** | 5 | 3 | **4** | **4** | **8** |
| Accent + Banvel[b] | 8–24 in.[a] | 0.67 oz + 0.5 pt | 7 | 7 | 7 | 7 | 7 | **8** | 5 | 6 | 6 | **8** |
| **Beacon** | **Pretassel[c]** | **0.76 oz** | **8** | 5 | 6 | **8** | 6 | 6 | 5 | 7 | 5 | 7 |
| Beacon + Banvel[b] | 4–24 in.[d] | 0.38 oz + 0.5 pt | **8** | 7 | 7 | 7 | 6 | 6 | 5 | 7 | 7 | **8** |
| **NorthStar** | **4–36 in.[c]** | **5 oz** | **8** | 6 | 7 | **8** | 6 | 6 | 5 | **8** | 7 | 6 |
| Spirit | 4–24 in.[c] | 1.00 oz | **8** | 5 | 6 | 7 | 6 | 6 | 5 | 7 | 5 | 7 |
| **Spirit + Banvel[b]** | **4–24 in.[d]** | **1.00 oz + 0.5 pt** | **8** | 7 | 7 | **8** | **7** | 6 | 5 | **8** | 7 | **8** |
| Lightning[e] | ≤ 20 in.[c] | 1.28 oz | **8** | 6 | 4 | 5 | 5 | 6 | 4 | 6 | 6 | 6 |
| **Permit + Banvel[b]** | **8–36 in.[a]** | **0.67 oz + 0.5 pt** | 7 | 6 | 7 | **8** | **8** | 6 | 5 | **8** | 7 | **8** |
| glyphosate[f] | Pretassel | 1–2% solution | **8** | **8** | **8** | **8** | **8** | 7 | 6 | **8** | **8** | **9** |
| **glyphosate[g,h]** | **≤ 30 in.** | **0.75 lb a.e.** | **8** | 7 | 7 | 7 | 7 | 7 | 5 | 6 | 7 | **8** |
| ReadyMaster ATZ[h] | ≤ 12 in. | 2.0 qt | **8** | 7 | 7 | 7 | 7 | 7 | 5 | 6 | 7 | **8** |
| **Liberty[i]** | **≤ 24 in.** | **1.75 pt** | 7 | 6 | 6 | 6 | 6 | 5 | N | 6 | N | 5 |
| Liberty ATZ[i] | ≤ 12 in. | 2.5 pt | 7 | 6 | 6 | 6 | 6 | 5 | N | 6 | N | 5 |

**9** = excellent, **8** = good, 7 = fair, 6 = poor, 5 or less = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

[a]Use drop nozzles; do not spray over whorl of corn.

[b]Use only NIS as adjuvant.

[c]Use drop nozzles with Beacon, NorthStar, Lightning, or Spirit in corn more than 20 inches tall.

[d]Use drop nozzles if corn is more than 12 inches tall.

[e]Use only with Clearfield (CL) corn hybrids.

[f]Glyphosate used as a spot treatment in corn.

[g]See Table 8 for a listing of glyphosate formulations registered for use in glyphosate-resistant corn hybrids.

[h]Use only with glyphosate-resistant corn hybrids.

[i]Use only with Liberty Link (glufosinate-resistant) corn hybrids.

**Table 26. Soybean "post" herbicides for partial control or suppression of perennial weeds**

| Herbicide | Artichoke, Jerusalem | Bindweed, field or hedge | Dock, curly | Dogbane, hemp | Horsenettle | Milkweed, common | Milkweed, honeyvine (climbing) | Morningglory, bigroot | Nutsedge, yellow | Pokeweed | Smartweed, swamp | Thistle, Canada |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| glyphosate[a,c] 0.56 lb a.e. | **8** | 7 | 6 | 7 | 7 | 7 | 7 | 5 | 6 | **8** | 7 | **8** |
| glyphosate[b,c] 1–2% | **8** | **8** | 7 | **8** | **8** | **8** | 7 | 6 | 7 | **9** | **8** | **9** |
| Classic[d] | 7 | 7 | 6 | N | 5 | 6 | 7 | N | 6 | 6 | N | 7 |
| Synchrony XP[e] | 7 | 7 | 6 | N | 5 | 7 | 7 | N | 6 | 6 | N | 7 |
| Pursuit | **8** | N | 6 | N | 7 | N | N | N | 6 | N | N | 6 |
| Extreme[a] | **8** | 7 | 6 | 7 | 7 | 7 | 7 | 5 | 6 | **8** | 7 | **8** |
| Raptor | **8** | 6 | N | N | N | N | N | N | 6 | N | N | 7 |
| Basagran[d] | 7 | 5 | N | N | 5 | N | N | N | **8** | N | N | **8** |
| Ultra Blazer[f] | 6 | 6 | N | N | 6 | 6 | N | 5 | N | N | N | 6 |
| Cobra[g] | 6 | 6 | N | N | 6 | 6 | N | 6 | N | N | 6 | 6 |
| Flexstar | 6 | 6 | N | N | 6 | N | 6 | N | 5 | N | N | 6 |

**9** = excellent, **8** = good, 7 = fair, 6 = poor, 5 or less = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

[a]Use only with glyphosate-resistant soybean varieties.

[b]Spot treatment with glyphosate solutions on a spray-to-wet basis before bloom stage.

[c]See Table 8 for a listing of glyphosate formulations.

[d]Use either the high rate or a split application for this degree of control.

[e]Use only with STS (sulfonylurea-tolerant) soybean varieties at rates greater than 0.375 oz/A.

[f]Label specifies high rate and favorable environmental conditions required for suppression.

[g]Label specifies the use of COC and a maximum of 6-leaf stage for suppression.

# 3

# Weed Control for Small Grains, Pastures, and Forages

Good weed control is necessary for maximum production of high-quality small grains, pastures, and forages in Illinois. When properly established, these crops usually can compete effectively with weeds, so the need for herbicide applications is minimized. However, weeds can sometimes become significant problems and warrant control. For example, wild garlic is considered the worst weed problem in wheat in southern Illinois. Because its life cycle is similar to that of winter wheat, wild garlic can establish itself with the wheat, grow to maturity, and produce large quantities of aerial bulblets by wheat harvest time. Economics often makes it necessary to control wild garlic in winter wheat to minimize dockage.

In pastures, woody and herbaceous perennials can become troublesome. Annual grasses and broadleaf weeds such as chickweed and henbit may cause problems in hay crops. By proper management, many of these weed problems can be controlled effectively.

Several herbicide labels carry the following groundwater warnings under either the environmental hazard or the groundwater advisory section: "X is a chemical that can travel (seep or leach) through soil and enter groundwater that may be used as drinking water. X has been found in groundwater as a result of its use as a herbicide. Users of this product are advised not to apply X where the soils are very permeable (that is, well-drained soils such as loamy sands) and the water table is close to the surface." Table 1 lists herbicides that carry this warning. A few labels also warn against contamination of surface water.

## Small Grains

Good weed control is critical for maximum production of high-quality small grains. Often, problems with weeds may be dealt with before the crop is established. For example, some broadleaf weeds can be controlled effectively in the late fall with **2,4-D** or dicamba **(Banvel** or **Clarity),** or with glyphosate (see Table 2 for various glyphosate products), after corn or soybean harvest, if seeding is not too late.

Tillage helps control weeds. Although generally limited to preplant or postharvest operations, tillage can destroy many annual weeds and help suppress certain perennials. Good cultural practices such as proper seeding rate, optimal soil fertility, and timely planting help to ensure the establishment of an excellent stand and a crop that is better able to compete with weeds.

Winter annual grasses such as downy brome and cheat are very competitive in winter wheat. Illinois wheat producers are often limited to preplant tillage operations for control of these species, as few herbicides have label clearances for annual grass control in winter wheat. If there is a severe infestation of downy brome or cheat, planting an alternative crop or spring crop may be best for that field.

A decision to use postemergence herbicides for broadleaf weed control in small grains should be based on several considerations:

1. *Nature of the weed problem.* Identify the species present and consider the severity of the infestation. Also note the size of the weeds. Weeds are usually best controlled while small.

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

**Table 1. Herbicides, formulations, and special statements**

| Trade name | Common name | Formulation | Restricted use | Groundwater advisory | Key word |
|---|---|---|---|---|---|
| 2,4-D amine | 2,4-D amine | 3.8 lb a.e./gal.[a] | — | Yes | **Danger**[b] |
| 2,4-D ester | 2,4-D ester | 3.8 lb a.e./gal.[a] | — | — | Caution |
| Aim | carfentrazone-ethyl | 1.9 lb/gal. | — | — | Caution |
| Balan | benefin | 60% | — | — | Warning |
| Banvel | dicamba | 4 lb a.e./gal.[a] | — | Yes | Warning |
| Buctril | bromoxynil | 2 lb/gal. | — | — | Warning |
| Butyrac 200 or Butoxone 200 | 2,4-DB | 2 lb a.e./gal.[a] | — | Yes | **Danger**[b] |
| Cimarron | metsulfuron | 60% | — | — | Caution |
| Cimarron Max | metsulfuron + dicamba + 2,4-D | 75% 12.25% + 35.25% | — | — | **Danger**[b] |
| Clarity | dicamba | 4 lb a.e./gal. | — | Yes | Caution |
| Crossbow | 2,4-D + triclopyr | 2 + 1 lb a.e./gal.[a] | — | Yes | Caution |
| Curtail | 2,4-D + clopyralid | 2 + 0.38 lb a.e./gal.[a] | — | Yes | **Danger**[b] |
| Eptam | EPTC | 7 lb/gal., 20% | — | — | Caution |
| Gramoxone Max | paraquat | 3.0 lb/gal. | Yes | — | **Danger**[b] |
| Harmony Extra | thifensulfuron + tribenuron | 75% | — | — | Caution |
| Harmony GT XP | thifensulfuron | 75% | — | — | Caution |
| Many (Table 2) | glyphosate | several | — | — | Caution |
| MCPA | MCPA | several | — | — | Warning |
| Olympus | propoxycarbazone | 70% | — | — | Caution |
| Osprey | mesosulfuron | 4.5% | — | — | Caution |
| Poast Plus | sethoxydim | 1 lb/gal. | — | — | Caution |
| Pursuit | imazethapyr | 2 lb/gal., 70% | — | — | Caution, Warning |
| Raptor | imazamox | 1 lb/gal. | — | — | Caution |
| Select | clethodim | 2 lb/gal. | — | — | Warning |
| Sencor | metribuzin | 75% | — | Yes | Caution |
| Sinbar | terbacil | 80% | — | — | Caution |
| Spike | tebuthiuron | 20% | — | Yes | Caution |
| Stinger | clopyralid | 3 lb a.e./gal.[a] | — | Yes | Caution |
| Treflan | trifluralin | 4 lb/gal., 5 lb/gal., 10G | — | — | Caution |
| Velpar L | hexazinone | 2 lb/gal. | — | Yes | **Danger**[b] |
| Weedmaster/Brash | dicamba + 2,4-D | 1 + 2.87 lb/gal. | — | Yes | **Danger**[b] |

[a]a.e. = acid equivalent for these herbicides. All others are active ingredient (a.i.) formulations.
[b]**Danger:** Check label for safety equipment and precautions.

2. *Stage of the crop.* Most herbicides are applied after full-tiller until the boot stage. Do not apply herbicides from the boot stage to the hard-dough stage of small grains (see Figure 1 for a description of growth stages of small grains).
3. *Herbicide activity.* Determine crop tolerance and weed susceptibility to herbicides by referring to Tables 3 and 4. The lower rates in Table 4 are for more easily controlled weeds and the higher rates for the more difficult-to-control species. Tank mixes may broaden the weed spectrum and thereby improve control; check the herbicide label for registered combinations.
4. *Presence of a legume underseeding.* Usually 2,4-D ester formulations and certain other herbicides listed in Table 4 should not be applied because they may damage the legume underseeding.

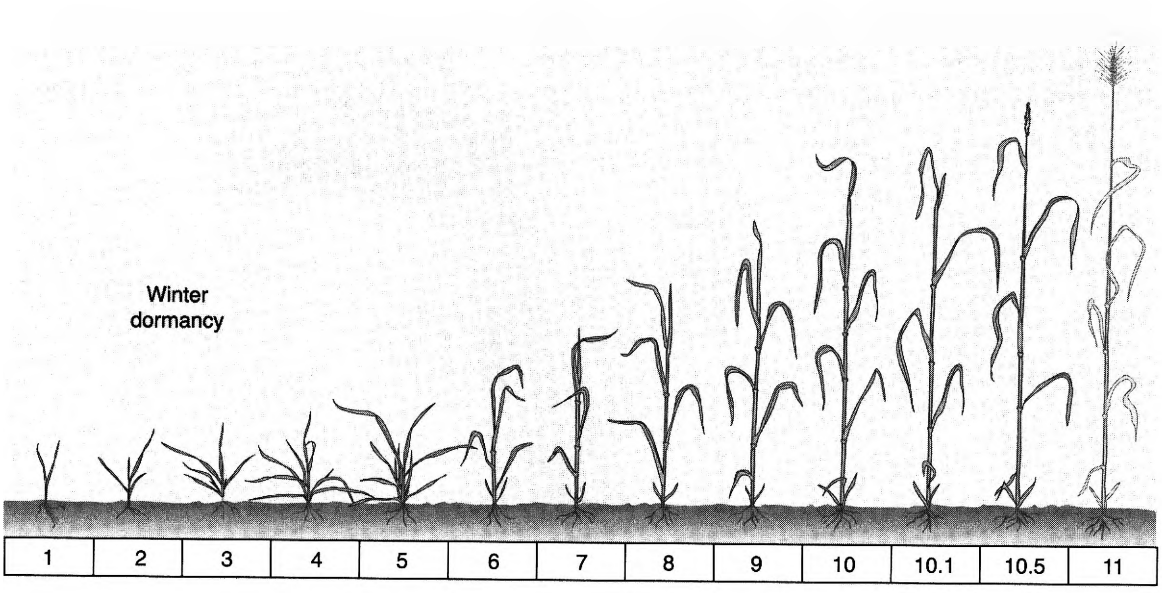


**Figure 1. Growth stages of small grains (wheat shown). Numbers shown represent growth stages according to Feekes' scale.**

5. *Economic justification.* Consider the treatment cost in terms of potential benefits, such as the value of increased yield, improved quality of grain, and ease of harvesting the crop.

Table 4 outlines current suggestions for weed-control options in wheat and oats, the two small grains most commonly grown in Illinois. Please refer to Table 5 for grazing-restriction information concerning herbicides used in small grains. Always consult the herbicide label for specific information about the use of a given product.

### SEEDLING

**Stage 1.** The coleoptile, a protective sheath that surrounds the shoot, emerges. The first leaf emerges

**Table 2. Incomplete list of glyphosate products for use in small grains, pastures, and forages**

| Trade name | Company | Formulation | Active ingredient (a.i.) per gallon or pound | Acid equivalent (a.e.) per gallon or pound |
|---|---|---|---|---|
| Roundup UltraMax | Monsanto | 5L | 5 lb | 3.68 lb |
| Roundup Original | Monsanto | 4L | 4 lb | 3 lb |
| Roundup Original Max | Monsanto | 5.5L | 5.5 lb | 4.5 lb |
| Roundup Weathermax | Monsanto | 5.5L | 5.5 lb | 4.5 lb |
| Touchdown Hitech | Syngenta | 6.16L | 6.16 lb | 5 lb |
| Touchdown Total | Syngenta | 5.14L | 5.14 lb | 4.17 lb |
| Glyfos | Cheminova | 4L | 4 lb | 3 lb |
| Glyphomax | Dow AgroSciences | 4L | 4 lb | 3 lb |
| Glyphomax Plus | Dow AgroSciences | 4L | 4 lb | 3 lb |
| Credit | Nufarm | 4L | 4 lb | 3 lb |
| Gly-Flo | Micro Flo | 4L | 4 lb | 3 lb |
| Cornerstone | Agriliance | 4L | 4 lb | 3 lb |
| Rattler | Helena | 4L | 4 lb | 3 lb |
| Mirage | UAP | 4L | 4 lb | 3 lb |
| Buccaneer | Tenkoz | 4L | 4 lb | 3 lb |
| Honcho | Monsanto | 4L | 4 lb | 3 lb |

**Table 3. Effectiveness of herbicides on weeds in small grains**

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rate and weed size or growth stage. Performance may vary due to weather and soil conditions or other variables.

| | Susceptibility to herbicide | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Weed | 2,4-D | Aim | Banvel or Clarity | Buctril | Harmony Extra | Harmony GT XP | MCPA | Olympus | Osprey | Stinger |
| **Winter annual** | | | | | | | | | | |
| Buckwheat, wild | 5 | 5 | **9** | **9** | **8** | **8** | 6 | 5 | N | **8** |
| Chickweed, common | 5 | N | 7 | 6 | **9** | 6 | 5 | – | – | N |
| Henbit | 5 | 5 | 7 | **8** | **9** | 7 | 7 | 7 | 7 | N |
| Horseweed (marestail) | **8** | N | **8** | 7 | **8** | 5 | **8** | – | – | **8** |
| Lettuce, prickly | **9** | 5 | **8** | 6 | **8** | 7 | **8** | N | N | **8** |
| Mustard spp., annual | **9** | **8** | 7 | **8** | **9** | **9** | **8** | **8** | N | N |
| Pennycress, field | **9** | **9** | 7 | **8** | **9** | **9** | **8** | **9** | N | N |
| Shepherd's purse | **9** | 7 | **8** | **9** | **9** | **9** | **8** | **9** | 7 | N |
| **Summer annual** | | | | | | | | | | |
| Lambsquarters, common | **9** | **8** | **9** | **9** | **9** | **9** | **9** | N | N | N |
| Pigweed spp. | **9** | **8** | **9** | 7 | **9** | **9** | **8** | 7 | 7 | N |
| Ragweed, common | **9** | 6 | **9** | **9** | **8** | 5 | **9** | – | – | **8** |
| Ragweed, giant | **9** | 4 | **9** | **8** | 5 | 5 | **9** | – | – | **8** |
| Smartweed, Pennsylvania | 7 | 5 | **9** | **8** | **9** | **9** | 7 | N | N | 7 |
| **Perennial** | | | | | | | | | | |
| Dandelion | **9** | N | **8** | 6 | 6 | 5 | **8** | – | – | **9** |
| Garlic, wild | | | | | | | | | | |
| Aerial bulblets | 6* | N | 5 | N | **9** | **9** | 5 | – | – | N |
| Underground bulbs | N | N | N | N | 5 | 5 | N | – | – | N |
| Thistle, Canada | 7 | N | 7 | 5 | 6 | 4 | 6 | – | – | **9** |

9 = excellent, 8 = good, 7 = fair, 6 = poor, 5 or 4 = unsatisfactory, N = no control or not labeled, – = unknown. Boldface indicates acceptable control.
*2,4-D ester at maximum use rate.

through the coleoptile, and other leaves follow in succession from within the sheath of the previously emerging leaf.

### TILLERING

**Stages 2 to 3.** Tillers (shoots) emerge on opposite sides of the plant from buds in the axils of the first and second leaves. The next tillers may arise from the first shoot at a point above the first and second tillers or from the tillers themselves. This process is repeated until a plant has several shoots.

**Stages 4 to 5.** The leaf sheaths lengthen, giving the appearance of a stem. The true stems in both the main shoot and the tillers are short and concealed within the leaf sheaths.

### JOINTING

**Stage 6.** The stems and leaf sheaths begin to elongate rapidly, and the first node (joint) of the stem is visible at the base of the shoot.

**Stage 7.** The second node (joint) of the stem is visible. The next-to-last leaf is emerging from within the sheath of the previous leaf but is barely visible.

**Stage 8.** The last leaf, the "flag leaf," is visible but still rolled.

**Stage 9. Preboot stage.** The ligule of the flag leaf is visible. The head begins to enlarge within the sheath.

**Stage 10. Boot stage.** The sheath of the flag leaf is completely emerged and distended due to the enlarging but not yet visible head.

**Table 4. Weed control in small grains**

| Herbicide | Broadcast rate/acre | Remarks (See Table 5 for grazing restrictions.) |
|---|---|---|
| **Oats and wheat with legume underseeding** | | |
| 2,4-D amine, 3.8 lb a.e. | ½ to 1½ pt | Winter wheat is more tolerant than oats. Apply in spring after full-tiller but before joint stage. Do not treat in the fall. Use lower rate if underseeded with legume. Some legume damage may occur. May be used as preharvest treatment at 1 to 2 pt per acre during hard-dough stage. |
| Buctril 2E | 1 to 1½ pt | Apply Buctril alone to fall-seeded small grains in the fall or spring before the boot stage. Weeds are best controlled before the 3- to 4-leaf stage. Buctril 2E may be applied at 1 to 1½ pt per acre to small grains underseeded with alfalfa. |
| MCPA amine | ¼ to 1½ pt | Less likely than 2,4-D to damage oats and legume underseeding. Apply from 4-leaf stage to early boot stage. Rate varies with crop and weed size and presence of legume underseeding. |
| **Oats and wheat without legume underseeding** | | |
| Aim EW | 0.5 to 2.0 oz | *Do not use with legume underseeding.* Apply to winter wheat, barley, and oats from 30 days before planting up to the jointing stage of growth. Make applications to actively growing weeds up to 4 in. tall and rosettes less than 3 in. across. Larger and harder-to-control weeds require higher rates and tank-mix combinations. |
| Banvel or Clarity, 4 lb a.e. | 2 to 4 fl oz | *Do not use with legume underseeding.* In fall-seeded wheat, apply before jointing stage. In spring-seeded oats, apply before oats exceed 5-leaf stage. Clarity may be used as a preharvest treatment when wheat is in the hard-dough stage and the green color is gone from the nodes of the stem. It is not recommended that wheat being grown for seed be treated with Clarity because a reduction in germination or vigor may occur. |
| Harmony Extra or Harmony GT XP | 0.3 to 0.6 oz | *Do not use with legume underseeding.* Harmony Extra and Harmony GT XP have similar labels. Make applications to wheat after the crop is in the 2-leaf stage but before the flag leaf is visible. For spring oats, make applications after the crop is in the 3-leaf stage but before jointing. The use rate for spring oats is 0.3 to 0.4 oz per acre. Do not use on "Ogle," "Porter," or "Premier" oat varieties, as crop injury may result. Wild garlic should be less than 12 in. tall, with 2 to 4 in. of new growth. Annual broadleaf weeds should be past the cotyledon stage, actively growing, and less than 4 in. tall or across. Nonionic surfactant at 0.25% volume per volume (v/v) should be included in the spray mixture. When liquid fertilizer is used as the carrier, use 1/16 to ¼% v/v surfactant. *Temporary stunting and yellowing may occur when Harmony Extra is applied using liquid fertilizer solution as the carrier.* These symptoms are intensified with the addition of surfactant. Without the addition of surfactant, wild garlic control may be erratic. Do not plant any crop other than wheat or oats within 45 days after application. |
| Stinger, 3 lb a.e. | ¼ to ⅓ pt | *Do not use with legume underseeding.* Apply to small grains from the 3-leaf stage up to the early boot stage. For control of Canada thistle, ⅓ pt per acre should be used. For control of additional weeds, other postemergence herbicides registered for use in wheat and oats may be tank-mixed with Stinger. |

**Table 4. Weed control in small grains (cont.)**

| Herbicide | Broadcast rate/acre | Remarks (See Table 5 for grazing restrictions.) |
|---|---|---|
| **Wheat only** | | |
| 2,4-D ester, 3.8 lb a.e. | ½ to 1 pt | *Do not use with legume underseeding.* Apply in the spring after full-tiller but before joint stage. For *preharvest treatment,* apply 1 to 2 pt per acre during hard-dough stage. For control of wild garlic or wild onion, apply 1 to 2 pt in the spring when wheat is 4 to 8 in. tall, after tillering but before jointing. *These rates may injure the crop and only suppress wild garlic.* |
| glyphosate (Table 2), 3 lb a.e./gal. | 1 to 2 pt | *Do not use with legume underseeding.* Apply as a *preharvest treatment only* after the hard-dough stage of grain (30% or less moisture) and at least 7 days before harvest. Application rates will depend on the glyphosate formulation used (see respective labels). It is not recommended that wheat being grown for seed be treated with glyphosate because a reduction in germination or vigor may occur. |
| Olympus | 0.6 to 0.9 oz | *Do not use with legume underseeding.* Controls cheatgrass and certain broadleaf weeds. Apply to small, actively growing weeds after wheat emergence but before the jointing stage of growth. Applications before wheat tiller initiation have a greater risk of stunting the crop. Cheat and Japanese brome are more susceptible than downy brome and generally are controlled adequately in both fall and spring with the 0.6 oz rate. Fall applications at 0.9 oz are recommended for downy brome control. Apply with a nonionic surfactant at 0.25% to 0.5% v/v. Liquid nitrogen fertilizer can be used as a spray carrier. Fall applications in liquid fertilizer solutions should not exceed 50% liquid nitrogen and no more than 30 pounds of actual nitrogen per acre. Only add 0.25% v/v surfactant when applied with fertilizer carrier. Can be tank-mixed with 2,4-D, Ally, Amer, Finesse, Harmony Extra, MCPA, Banvel, Clarity, Starane, or Rave. STS soybeans can be planted 4 months after Olympus treatment. Cotton, grain sorghum, sunflowers, and non-STS soybeans can be planted 12 months after Olympus treatment if cumulative precipitation exceeds 24 inches. Corn can be planted 18 months after Olympus application if cumulative precipitation exceeds 30 inches. Rotation to other crops or with shorter intervals requires successful completion of a field bioassay, and no sooner than 4 months after Olympus application. Risk of Olympus carryover is greatest on high-pH soils. |
| Osprey | 4.75 oz | *Do not use with legume underseeding.* Controls Italian (annual) ryegrass. Apply to actively growing weeds after wheat emergence but before the jointing stage of growth. Applications before wheat tiller initiation have a greater risk of stunting the crop. Must be applied with MSO, or nonionic surfactant plus nitrogen fertilizer adjuvants. Topdress liquid nitrogen fertilizer applications are not recommended within 21 days of Osprey treatment because of the increased potential for crop injury. Can be tank-mixed with Ally, Finesse, Harmony Extra, MCPA ester, or Starane. Do not plant barley, sunflowers, soybeans, or cotton until 90 days; corn until 12 months; or any other crop until 10 months after Osprey application. |
| Paramount | 5.3 oz | *Do not use with legume underseeding.* Apply *prior to wheat emergence only.* Plant wheat at least 1 inch deep; shallow planting (< 1 inch deep) may result in possible crop injury. Do not apply more than 16 oz per acre per year. Do not plant crops other than wheat or sorghum for at least 10 months after application. Do not allow livestock to graze treated areas. Do not feed treated forage, hay, silage, straw, or seed to livestock. |

**Table 5. Grazing restrictions for small-grain herbicides**

| Herbicide name | | | | Days after treatment before use | | | |
|---|---|---|---|---|---|---|---|
| | | | | Graze green | | | |
| Trade | Common | Crops | Applied | Beef | Dairy | Feed straw | Withdraw for meat |
| Aim | carfentrazone-ethyl | wheat, oats, barley | Prejoint | 7 | 7 | 7 | 7 |
| Banvel or Clarity | dicamba | wheat, oats, barley | Prejoint | 0 | 7 | 37 | 30 |
| Buctril | bromoxynil | wheat, oats, rye, barley | Preboot | 45 | 45 | 45 | 45 |
| Harmony Extra | thifensulfuron + tribenuron | wheat, barley, spring oats | Prejoint | No | No | Yes | 0 |
| Harmony GT XP | thifensulfuron | wheat, barley, spring oats | Prejoint | No | No | Yes | 0 |
| Many | 2,4-D | wheat, oats, rye, barley | Prejoint | 14 | 14 | 0 | 14 |
| Many | 2,4-D, late | wheat, oats, rye, barley | Before harvest | No | No | No | ...* |
| Many | glyphosate | wheat | Before harvest | 14 | 14 | 14 | ...* |
| Many | MCPA | wheat, oats, rye, barley | Prejoint | 7 | 7 | 0 | 7 |
| Olympus | propoxycarba-zone | wheat | Prejoint | ...* | ...* | ...* | ...* |
| Osprey | mesosulfuron | wheat | Prejoint | ...* | ...* | ...* | ...* |
| Paramount | quinclorac | wheat | Preemergence | No | No | No | ...* |
| Stinger | clopyralid | wheat, oats, barley | Preboot | 7 | 7 | No | 7 |

*No withdrawal information available.

#### HEADING

**Stages 10.1 to 10.5.** Heads of the main stem usually emerge first, followed in turn by heads of the tillers in order of their development. Heading continues until all heads are out of their sheaths. The uppermost internode continues to lengthen until the head is raised several inches above the uppermost leaf sheath.

#### FLOWERING

**Stages 10.5.1 to 10.5.3.** Flowering progresses in order of head emergence. Unpollinated flowers result in no kernels.

**Stage 10.5.4. Premilk stage.** Flowering is complete. The inner fluid is abundant and clear in the developing kernels of the flowers pollinated first.

#### RIPENING

**Stage 11.1. Milk stage.** Kernel fluid is milky white from the accumulating starch.

**Stage 11.2. Dough stage.** Kernel contents are soft and dry (doughy) as starch accumulation continues. The plant leaves and stems are yellow.

**Stage 11.3.** The kernel is hard, difficult to divide with the thumbnail.

**Stage 11.4.** The kernel is ripe for cutting and fragments when crushed. The plant is dry and brittle.

For annual broadleaf weeds, postemergence herbicides such as **2,4-D, Aim, Banvel** or **Clarity, Buctril** (bromoxynil), and **MCPA** can provide good control of susceptible species (Table 3). Herbicides must be applied during certain growth stages of the crop to avoid crop injury and for optimal weed control. Refer to Figure 1 for a description of the growth stages of small grains.

Some perennial broadleaf weeds may not be controlled satisfactorily with the low herbicide rates used in small grains, and higher rates are not advisable because they can cause serious injury to crops. To control perennial weeds, translocated herbicides such as **2,4-D, Banvel, Clarity,** or **glyphosate,** in combination with tillage after small-grain harvest or after soybean harvest but before establishing small grains, may be the best approach.

**Stinger** (clopyralid) may be used to control broadleaf weeds in wheat, oats, and barley. Stinger controls

Canada thistle, as well as a number of annual broadleaf weeds (Table 3).

Wild garlic continues to be a serious weed problem in winter wheat. **Harmony GT XP** (thifensulfuron), applied in the spring at 0.3 to 0.6 ounce of 75DF per acre, effectively controls wild garlic aerial bulblets and some underground bulbs as well. **Harmony Extra** also helps control chickweed, henbit, common lambsquarters, smartweed, and several species of mustard. See Tables 3 and 4 for more information on controlling weeds in small grains.

**Glyphosate** (Table 2) may be used as a preharvest treatment in wheat for control of annual and certain perennial weed species. Applications should be made only after the hard-dough stage of the grain (30 percent or less grain moisture) and at least 7 days before harvest.

## Grass Pastures

Unless properly managed, broadleaf weeds can become a serious problem in grass pastures. They can compete directly with forage grasses and reduce the nutritional value and longevity of the pasture. Certain species, such as white snakeroot and poison hemlock, are also poisonous to livestock and may require special consideration.

Perennial weeds are of great concern in pasture management. They can exist for many years, reproducing from both seed and underground parent rootstocks. Occasional mowing or grazing helps control certain annual weeds, but perennials can grow back from underground root reserves unless long-term control strategies are implemented.

Certain biennials can also flourish in grass pastures. The first year, they exist as a prostrate rosette, so that even close mowing does little to control their growth. The second year, biennials produce a seed stalk and a deep taproot. If these weeds are grazed or mowed at this stage, root reserves can enable the plant to grow again, thereby increasing its chance of surviving to maturity.

In general, the use of good cultural practices such as maintaining optimal soil fertility, rotational grazing, and periodic mowing can help keep grass pastures in good condition and more competitive with weeds. Where broadleaf weeds become troublesome, however, **2,4-D, Banvel, Clarity, Curtail** (2,4-D + clopyralid), **Stinger,** or **Weedmaster/Brash** (dicamba + 2,4-D) may be used. **Glyphosate** (Table 2) also may be used as a spot treatment, and **Crossbow** (2,4-D + triclopyr) and **Cimarron Max** (2,4-D + dicamba + metsulfuron methyl) are labeled for control of broadleaf and woody plant species in grass pastures. **Spike 20P** (tebuthiuron) also may be used in grass pastures for control of brush and woody plants (see Tables 6 and 7 for additional information).

Proper identification of target weed species is important. As shown in Table 6, weeds vary in their susceptibility to herbicides. Timing of herbicide application also may affect the degree of weed control. Annuals and biennials are most easily controlled while young and relatively small. A fall or early-spring herbicide application works best if biennials or winter annuals are the main weed problem. Summer annuals are most easily controlled in the spring or early summer. Apply translocated herbicides to control established perennials when the weeds are in the bud-to-bloom stage. Perennials are most susceptible at this reproductive stage because translocated herbicides can move downward with food reserves to the roots, thus killing the entire plant.

For control of woody brush, apply **2,4-D, Banvel** or **Clarity,** or **Crossbow** when the plants are fully leafed and actively growing. Where regrowth occurs, a second treatment may be needed in the fall. During the dormant season, oil-soluble formulations of **2,4-D** or **Crossbow** may be applied in fuel oil to the trunk. **Spike** controls many woody perennials and should be applied to the soil in the spring. **Spike** requires rainfall to move it into the root zone of target species. **Cimarron** may also be used in broadcast or basal soil applications for control of multiflora rose and other broadleaf weed species.

The weed-control options in grass pastures are shown in Table 7. Refer to Table 8 for information concerning grazing restrictions for herbicides used in grass pastures. Be cautious with any pesticide, and always consult the herbicide label for specific information about the use of a given product.

## Forage Legumes

Weed control is important in managing forage legumes. Weeds can reduce the vigor of legume stands, reducing yield and forage quality. Good management begins with weed control that prevents weeds from becoming serious problems.

### Establishment

To minimize problems, prepare the seedbed properly so that it is firm and weed free. Select an appropriate legume variety. If you use high-quality seed and follow the recommendations for liming and fertility, the legume crop may compete well with many weeds and reduce the need for herbicides.

In fields where companion crops such as oats are used to reduce weed competition, seed the small grain at half the rate for grain production to ensure that the legumes become established with minimum stress. If the legume is seeded without a companion crop (direct-seeded), the use of an appropriate herbicide is suggested.

**Table 6. Effectiveness of herbicides on weeds in grass pastures**

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rate and weed size or growth stage. Performance may vary due to weather and soil conditions or other variables.

| | Susceptibility to herbicide | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Weed | 2,4-D | Banvel or Clarity | Cimarron | Cimarron Max | Crossbow | Curtail | glyphosate[a] | Stinger |
| **Winter annual** | | | | | | | | |
| Horseweed (marestail) | **8** | **9** | **9** | **9** | **9** | **8** | **9** | **8** |
| Pennycress, field | **9** | **8** | **8** | **8** | **9** | **8** | **9** | N |
| **Summer annual** | | | | | | | | |
| Ragweed, common | **9** | **9** | 5 | **9** | **9** | **9** | **9** | **9** |
| Ragweed, giant | **9** | **9** | 5 | **9** | **9** | **9** | **9** | **9** |
| **Biennial** | | | | | | | | |
| Burdock, common | **9** | **9** | 7 | **9** | **9** | **8** | **8** | **8** |
| Hemlock, poison | **8** | **8** | 5 | 5 | **8** | 7 | **8** | N |
| Thistle, bull | **9** | **9** | **8** | **8** | **9** | **9** | **9** | **9** |
| Thistle, musk | **8** | **9** | **8** | **8** | **9** | **8** | **9** | **9** |
| **Perennial[b]** | | | | | | | | |
| Daisy, oxeye | 7 | **8** | **9** | **9** | **8** | **8** | **8** | **8** |
| Dandelion | **9** | **8** | **8** | **8** | **9** | **8** | 7 | **8** |
| Dock, curly | 7 | **9** | **9** | **9** | **9** | 7 | **8** | 7 |
| Goldenrod spp. | **8** | **8** | 5 | 5 | **8** | 7 | **9** | 5 |
| Hemlock, spotted water | **8** | **9** | N | 7 | **9** | 7 | **8** | 5 |
| Ironweed | 7 | **8** | 5 | 5 | **8** | 7 | **9** | 5 |
| Milkweed, common | 6 | 7 | 5 | 5 | 7 | 5 | 7 | 5 |
| Nettle, stinging | **8** | **8** | N | 5 | **8** | 7 | **8** | 5 |
| Plantain spp. | **9** | **8** | **8** | **8** | **9** | 7 | **8** | N |
| Rose, multiflora[c] | 7 | **8** | **9** | **9** | **9** | 7 | **8** | 5 |
| Snakeroot, white | 7 | **9** | N | **8** | **8** | 7 | **8** | 7 |
| Sorrel, red | 5 | **9** | **9** | **9** | **9** | 7 | **8** | 7 |
| Sowthistle, perennial | 7 | **9** | **8** | **8** | **9** | 7 | **8** | 7 |
| Thistle, Canada | 7 | **8** | **8** | **8** | **8** | **9** | **8** | **9** |

**9** = excellent, **8** = good, 7 = fair, 6 = poor, 5 = unsatisfactory, N = no control or not labeled. Boldface indicates acceptable control.

[a]Spot treatment only.

[b]Perennial weeds may require more than one application.

[c]Spike also is an effective herbicide for multiflora rose control (weed susceptibility = **9**).

## PREPLANT-INCORPORATED HERBICIDES

**Balan** (benefin), **Eptam** (EPTC), and **Treflan** (trifluralin) are registered for preplant incorporation for legumes that are not seeded with grass or small-grain companion crops. These herbicides control most annual grasses and some broadleaf weeds. In fall plantings, the weeds controlled include winter annuals such as downy brome and cheat. In spring plantings of legumes, the summer annual weeds controlled include foxtails, pigweeds, lambsquarters, crabgrass, and fall panicum. **Eptam** can help suppress johnsongrass, quackgrass, yellow nutsedge, and shattercane, in addition to controlling many annual grasses and some broadleaf weeds. These herbicides do not effectively control mustards, smartweed, or established perennials.

*(Text continues on page 122.)*

**Table 7. Broadleaf weed control in grass pastures**

| Herbicide | Rate/acre | Remarks (See Table 8 for grazing restrictions.) |
|---|---|---|
| 2,4-D, 3.8 lb a.e. (amine or low-volatile ester) | 2 to 4 pt | Broadleaf weeds should be actively growing. Higher rates may be needed for less susceptible weeds and some perennials. Spray bull or musk thistles in the rosette stage (spring or fall) while they are actively growing. Spray perennials such as Canada thistle in the bud stage or the fall regrowth stage. Spray susceptible woody species in the spring when leaves are fully expanded. *Do not apply to newly seeded areas or to grass when it is in boot-to-milk stage.* Be cautious of spray drift. |
| Banvel or Clarity, 4 lb a.e. | Annuals: ½ to 1½ pt<br>Biennials: ½ to 3 pt<br>Perennials: 2 to 4 pt | Use lower rates for susceptible annuals when they are small and actively growing and for susceptible biennials in the early rosette stage. Use higher rates for larger weeds, for less susceptible weeds, for established perennials in dense stands, and for certain woody brush species. Be cautious of spray drift. |
| Cimarron 60DF<br>or<br>Cimarron Max | 0.1 to 1 oz<br><br>Part A: 0.25 to 1 oz<br>Part B: 1 to 4 oz | Apply in the spring or early summer when weeds are less than 4 in. tall and are actively growing. Include a nonionic surfactant of at least 80% active ingredient at 1 to 2 qt per 100 gal. spray solution (¼ to ½% v/v). Bluegrass, bromegrass, orchardgrass, timothy, and native grasses such as bluestem and grama have demonstrated good tolerance. Bluegrass, bromegrass, and orchardgrass should be established for at least 6 months, timothy for 12 months, and fescue for 24 months at the time of application, or injury may result. *Application to fescue may result in stunting and seed head suppression.* For control of multiflora rose with broadcast applications, apply Cimarron/Cimarron Max at ½ ounce per acre when multiflora rose is less than 3 ft tall. Applications should be made in the spring, soon after multiflora rose is fully leafed. Cimarron/Cimarron Max can also be used as a spot and basal soil treatment for weed control. Consult the product label for species details regarding these types of applications. |
| Crossbow | Annuals: 1 to 2 qt<br>Biennials and herbaceous perennials: 2 to 4 qt<br>Woody perennials: 6 qt | Apply to foliage during warm weather when brush and broadleaf weeds are actively growing. When applying as a spot spray, thoroughly wet all foliage. See herbicide label for more specific rate recommendations. Be cautious of spray drift. Best control of multiflora rose occurs when application is made during early- to mid-flowering stage. |
| Curtail 2.38S | 2 to 4 qt/acre | Apply when weeds are young and actively growing. Grasses are tolerant, but new grass seedlings may be injured. For Canada thistle, apply to thistle at least 4 in. tall but before thistle reaches bud stage. *Do not spray pastures containing desirable forbs, such as alfalfa or clover, unless injury can be tolerated.* Do not use hay or straw from treated areas for composting or mulching on susceptible broadleaf crops. Refer to product label for additional precautions. |
| glyphosate (Table 2) | 1 to 2% solution (spot treatment) | Controls a variety of herbaceous and woody brush species, such as multiflora rose, brambles, poison ivy, and quackgrass. Spray foliage of target vegetation completely and uniformly but not to point of runoff. Avoid contact with desirable nontarget vegetation. Consult label for recommended timing of application for maximum effectiveness on target spe- |

**Table 7. Broadleaf weed control in grass pastures (cont.)**

| Herbicide | Rate/acre | Remarks (See Table 8 for grazing restrictions.) |
|---|---|---|
| glyphosate (Table 2) (cont.) | | cies. *No more than 1/10 of any acre should be treated at one time.* Further applications may be made in the same area at 30-day intervals. Use only where livestock movement can be controlled to prevent grazing for 14 days. Treated areas may be reseeded after 14 days. |
| Spike 20P | 10 to 20 lb | For control of brush and woody plants in rangeland and grass pastures. Requires sufficient rainfall to move herbicide into root zone. May kill or injure desirable legumes and grasses where contact is made. Injury is minimized by applying when grasses are dormant. Do not apply on or near field crops or other desirable vegetation. *Do not apply where soil movement is likely.* Refer to product label for additional restrictions. |
| Stinger 3S | 2/3 to 1 1/3 pt | Apply when weeds are young and actively growing. Grasses are tolerant, but new grass seedlings may be injured. For Canada thistle, apply to thistle at least 4 in. tall but before thistle reaches bud stage. *Do not spray pastures containing desirable forbs, such as alfalfa or clover, unless injury can be tolerated.* Do not use hay or straw from treated areas for composting or mulching on susceptible broadleaf crops. Refer to product label for additional precautions. |

**Table 8. Restrictions on herbicides used in permanent grass pastures**

| Herbicide name | | Days after treatment before use | | | | |
|---|---|---|---|---|---|---|
| | | Dairy | | Beef | | Slaughter |
| Trade | Common | Graze | Hay | Graze | Hay | |
| Banvel or Clarity | dicamba 1 pt | 7 | 37 | 0 | 0 | 30 |
| | 2 pt | 21 | 51 | 0 | 0 | 30 |
| | 4 pt | 40 | 70 | 0 | 0 | 30 |
| Cimarron | metsulfuron | 0 | 0 | 0 | 0 | 0 |
| Cimarron Max | metsulfuron + dicamba + 2,4-D | 7 | 37 | 0 | 0 | 30 |
| Crossbow | triclopyr + 2,4-D | 14 | NGS[a] | 0 | 0 | 3 |
| Curtail | 2,4-D + clopyralid | 14 | 30 | 0 | 30 | 7 |
| Many | 2,4-D | 7 to 14[b] | 30 | 0 | 30 | 3 to 7[b] |
| Many (Table 2) | glyphosate | | | | | |
| Spot treat | | 14 | 14 | 14 | 14 | 0 |
| Renovation | | 56 | 56 | 56 | 56 | 0 |
| Stinger[c] | clopyralid | 0 | 0 | 0 | 0 | 0 |
| Spike 20P | tebuthiuron | | | | | |
| < 20 lb/acre | | 0 | 365 | 0 | 365 | 0 |
| > 20 lb/acre | | ..... *Do not use for livestock for 1 year*..... | | | | |

[a]NGS = next growing season.
[b]Labels vary (withdrawal unnecessary if more than 14 days after treatment).
[c]Do not transfer livestock onto a broadleaf crop area within 7 days of grazing treated area.

**Table 9. Effectiveness of herbicides on weeds in legume and legume–grass forages**

This table compares the relative effectiveness of herbicides on individual weeds. Ratings are based on labeled application rate and weed size or growth stage. Performance may vary due to weather and soil conditions or other variables.

| Weed | Balan | Buctril | Butyrac | Eptam | glyphosate[a,b] | Gramoxone Max | Poast Plus | Pursuit | Raptor | Select | Sencor[a] | Sinbar | Treflan | Velpar |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Winter annual** | | | | | | | | | | | | | | |
| Brome, downy | **9** | N | N | 7 | **9** | **8** | **8** | 6 | 7 | **9** | **8** | **8** | **9** | **9** |
| Chickweed, common | **8** | 6 | 6 | 7 | **9** | **9** | N | **8** | **8** | N | **9** | 9 | 5 | **9** |
| Henbit | 5 | **8** | 6 | **8** | 7 | **9** | N | **7** | 7 | N | **9** | **9** | **8** | **8** |
| Mustard, wild | 5 | **8** | **8** | 6 | **9** | **8** | N | **9** | **9** | N | **9** | **9** | 5 | **9** |
| Pennycress, field | 5 | **9** | **8** | 6 | **9** | 7 | N | **9** | **9** | N | **9** | **9** | 5 | **9** |
| Shepherd's purse | 5 | **9** | **8** | 7 | **9** | **8** | N | **8** | **9** | N | **9** | **9** | 5 | **9** |
| Yellow rocket | 5 | 7 | 7 | 6 | **9** | 7 | N | **8** | **8** | N | **9** | **9** | 5 | **9** |
| **Summer annual** | | | | | | | | | | | | | | |
| Barnyardgrass | **9** | N | N | **9** | **9** | **8** | **9** | 7 | **8** | **9** | 7 | 7 | **9** | 7 |
| Crabgrass spp. | **9** | N | N | **9** | **9** | 6 | **9** | 7 | 7 | **9** | 7 | **8** | **8** | 7 |
| Foxtail spp. | **9** | N | N | **9** | **9** | **9** | **9** | **8** | **8** | **9** | 6 | **8** | **9** | 7 |
| Lambsquarters, common | **9** | **9** | **8** | **8** | **9** | **8** | N | 6 | **8** | N | **9** | **9** | **8** | **9** |
| Nightshade spp.[c] | N | **9** | 7 | **8** | **8** | **8** | N | **9** | **9** | N | 5 | **8** | 5 | 7 |
| Panicum, fall | **9** | N | N | **9** | **9** | **8** | **9** | 7 | **8** | **9** | 6 | **8** | **9** | 6 |
| Pigweed spp. | **9** | 7 | **8** | **9** | **9** | **8** | N | **9** | **9** | N | **9** | **8** | **8** | **9** |
| Ragweed, common | N | **9** | **9** | 7 | **9** | **8** | N | 7 | 7 | N | **8** | **8** | 5 | **8** |
| Smartweed, Pennsylvania | N | **9** | 6 | 5 | **8** | **8** | N | **9** | **9** | N | **8** | **8** | 5 | **8** |
| **Perennial** | | | | | | | | | | | | | | |
| Canada thistle | N | 5 | 5 | N | **8** | N | N | 6 | 6 | N | N | N | N | N |
| Dandelion | N | N | 7 | N | **8** | N | N | 6 | 6 | N | 7 | 6 | N | **8** |
| Dock, curly | N | N | 5 | N | 6 | N | N | 6 | 6 | N | 6 | 6 | N | 7 |
| Nutsedge, yellow | N | N | N | **8** | 7 | N | N | 6 | 6 | N | N | N | N | N |
| Orchardgrass | 5 | N | N | 6 | **8** | 5 | 6 | N | N | 7 | 5 | 5 | 5 | 7 |
| Quackgrass | 6 | N | N | 6 | **9** | 5 | 7 | 5 | 5 | **8** | 5 | 6 | 5 | 6 |

**9** = excellent, **8** = good, 7 = fair, 6 = poor, 5 = unsatisfactory, N = no control or not labeled.
[a]Glyphosate and Sencor are labeled for use in mixed legume–grass forages. No other herbicides are cleared for this use.
[b]Spot treatment only.
[c]Control of different species may vary.

**Balan, Eptam,** and **Treflan** *must* be thoroughly incorporated soon after application to avoid herbicide loss. They should be applied shortly before the legume is seeded to remain effective as long as possible into the growing season.

Weeds that emerge during crop establishment should be evaluated for their potential as problems. If they do not reduce the nutritional value of the forage or if they can be controlled by mowing, they should not be the primary focus of a postemergence herbicide application. For example, winter annual weeds do not compete vigorously with the crop after the first cutting in the

*(Text continues on page 128.)*

**Table 10. Weed control in legume forages**

| Herbicide | Legume | Time of application | Broadcast rate/acre | Remarks (See Table 11 for haying restrictions.) |
|---|---|---|---|---|
| **Seedling year** | | | | |
| Balan 60DF | Alfalfa, birdsfoot trefoil, red clover, ladino clover, alsike clover | Preplant incorporated | 2 to 2½ lb | Apply shortly before seeding. Do not use with any companion crop of small grains. |
| Buctril 2E | Alfalfa only | Postemergence | 1 to 1½ pt | Apply in the fall or spring to seedling alfalfa with at least 4 trifoliate leaves. Apply to weeds at or before the 4-leaf stage or 2 in. in height (whichever is first). May be tank-mixed with 2,4-DB for improved control of pigweed; however, crop burn may occur from this mixture, especially under warm, humid conditions. Eptam, previously used, may enhance Buctril burn to alfalfa. *Do not apply when temperatures are likely to exceed 70°F during or for 3 days following application* or when the crop is stressed. Do not add a surfactant or crop oil. |
| Butyrac 200 or Butoxone 200 | Alfalfa, birdsfoot trefoil, ladino clover, red clover, alsike clover | Postemergence | 1 to 3 qt (amine) | Use when weeds are less than 3 in. tall or less than 3 in. across if rosettes. Use higher rates for seedling smartweed or curly dock. May be tank-mixed with Poast Plus. *Do not use on sweet clover.* |
| Eptam 7E, 20G | Alfalfa, birdsfoot trefoil, lespedeza, clovers | Preplant incorporated | 3½ to 4½ pt (7E)<br>15 lb (20G) | Apply shortly before seeding. Do not use with any companion crop of small grains. |
| Gramoxone Max | Alfalfa only | Between cuttings | 0.70 pt | Apply within 5 days after cutting and before alfalfa regrowth is 2 in. Add surfactant according to label instructions. Do not apply more than twice during seedling year. *Gramoxone Max is a restricted use pesticide.* |
| Poast Plus | Alfalfa, birdsfoot trefoil | Postemergence | 1⅛ to 2¼ pt | Best grass control is achieved when applications are made prior to mowing. If tank-mixed with 2,4-DB, follow 2,4-DB harvest and grazing restrictions and add no additives with this tank mix. Do not apply more than a total of 9.75 pt of Poast Plus per acre in one season. |

**Table 10. Weed control in legume forages (cont.)**

| Herbicide | Legume | Time of application | Broadcast rate/acre | Remarks (See Table 11 for haying restrictions.) |
|---|---|---|---|---|
| **Seedling year (cont.)** | | | | |
| Pursuit 2AS or 70DG | Alfalfa only | Postemergence | 3 to 6 fl oz (2AS) 1.08 to 2.16 oz (70DG) | Apply when seedling alfalfa is in the second-trifoliate stage or larger and when the majority of weeds are 1 to 3 in. tall. For low-growing weeds, apply before the rosette exceeds 3 in. in diameter. Always include a nonionic surfactant or crop-oil concentrate and a liquid nitrogen fertilizer solution, and apply in 10 or more gallons of water per acre. When applied to seedling alfalfa, Pursuit may cause a temporary reduction in growth. Do not apply more than 6 fl oz or 2.16 oz per acre per year. *If applied under cool conditions (≤ 40°F), temporary stunting and yellowing of alfalfa may occur.* |
| Raptor 1AS | Alfalfa | Postemergence | 4 to 6 fl oz | Apply Raptor when seedling alfalfa is in the second-trifoliate stage or larger and the majority of weeds are 1 to 3 in. tall. Applications require the addition of a crop-oil concentrate or nonionic surfactant and a nitrogen fertilizer solution. Apply Raptor in 10 or more gallons of water per acre. A maximum of 6 fl oz of Raptor per season may be applied to alfalfa. When Raptor is applied to seedling alfalfa, there may be a temporary reduction in growth. |
| Select 2EC | Alfalfa | Postemergence | 6 to 8 fl oz | May be applied to seedling or established alfalfa grown for seed, hay, silage, green chop, or direct grazing. If tank-mixed with 2,4-DB, follow 2,4-DB grazing and harvest restrictions. Do not plant rotational crops until 30 days after Select application. |
| Treflan HFP, TR-10 | Alfalfa only | Preplant incorporated | 1 to 1½ pt (HFP) 5 to 7½ lb (TR-10) | May be applied as a preplant-incorporated treatment for preemergence control of certain grass and small-seeded broadleaf species. Some crop stand reduction and stunting may occur. |
| **Established stands** | | | | |
| Butyrac 200 or Butoxone 200 | Alfalfa only | Growing | 1 to 3 qt (amine) | Spray when weeds are less than 3 in. tall or less than 3 in. wide if rosettes. Fall treatment of fall-emerged weeds may be better than spring treatment. May be tank-mixed with Poast Plus. |
| glyphosate (Table 2) | Alfalfa<br>Alfalfa, clover, and alfalfa or clover–grass mixtures | Postemergence<br>Growing | 1 to 2% solution (spot treatment) | No more than 1/10 of any acre should be treated at one time. Further applications may be made in the same area at 30-day intervals. Avoid contact with desirable, nontarget vegetation because damage may occur. Refer to label for recommended timing of application for maximum effectiveness on target species. |

**Table 10. Weed control in legume forages (cont.)**

| Herbicide | Legume | Time of application | Broadcast rate/acre | Remarks (See Table 11 for haying restrictions.) |
|---|---|---|---|---|
| **Established stands (cont.)** | | | | |
| Gramoxone Max | Alfalfa only | Between cuttings | 0.70 pt | Between cuttings, treatments should be applied immediately after hay removal, within 5 days after cutting, and with less than 2 in. of growth. Weeds germinating after treatment are not controlled. *Gramoxone Max is a restricted use pesticide.* |
| Gramoxone Max | Alfalfa, clover | Dormant | 1.3 to 2.0 pt | For dormant season, apply after last fall cutting or before spring growth is 2 in. tall. Weeds should be succulent and growing at the time of application. Do not apply if fall regrowth is more than 6 in. *Gramoxone Max is a restricted use pesticide.* |
| Poast Plus 1E | Alfalfa | Postemergence | 1⅛ to 3¾ pt | Best grass control is achieved when applications are made prior to mowing. If tank-mixed with 2,4-DB, follow 2,4-DB grazing and harvest restrictions. Do not apply more than a total of 9.75 pt of Poast Plus per acre in one season. Applications up to 3.75 pt per acre can be made for perennial grass control. |
| Pursuit 2AS or 70DG | Alfalfa only | Postemergence | 3 to 6 fl oz (2AS)<br>1.08 to 2.16 oz (70DG) | Apply in the fall or spring to dormant or semi-dormant alfalfa (less than 3 in. of regrowth), or between cuttings. Do not apply more than 4 fl oz of the 2AS formulation or 1.44 oz of the 70DG formulation to alfalfa during the last year of the stand. Always include a nonionic surfactant or crop-oil concentrate and a liquid nitrogen fertilizer solution, and apply in 10 or more gallons of water per acre. *Applications made under cool conditions (≤ 40°F) may cause temporary stunting and yellowing of alfalfa.* |
| Raptor 1AS | Alfalfa | Postemergence | 4 to 6 fl oz | Raptor can be applied to dormant or semi-dormant alfalfa in the fall, winter, or spring, or between cuttings. Any application should be made before significant alfalfa growth or regrowth (3 in.). Applications require the addition of a crop-oil concentrate or nonionic surfactant and a nitrogen fertilizer solution. Apply Raptor in 10 or more gallons of water per acre. A maximum of 6 fl oz of Raptor per season may be applied to alfalfa. |
| glyphosate (Table 2) | Alfalfa | Last cutting | 1 to 2 pt (3 lb a.e./gal.) | For use in declining alfalfa stands prior to crop rotation. Apply before last cutting in fall or spring for control of certain perennial grass and broadleaf weed species. *Do not use for alfalfa grown for seed.* |

**Table 10. Weed control in legume forages (cont.)**

| Herbicide | Legume | Time of application | Broadcast rate/acre | Remarks (See Table 11 for haying restrictions.) |
|---|---|---|---|---|
| **Established stands (cont.)** | | | | |
| Select 2EC | Alfalfa | Postemergence | 8 to 16 fl oz | For control of annual grasses in established alfalfa, use a minimum of 8 fl oz per acre. If tank-mixed with 2,4-DB, follow 2,4-DB grazing and harvest restrictions. |
| Sencor 75DF | Alfalfa and alfalfa–grass mixtures | Dormant | ½ to 1⅓ lb | Apply once in the fall or spring before new growth starts. Rate is based on soil type and organic-matter content. Higher rates may injure grass component. Do not use on sandy soils or soils with pH greater than 7.5. |
| Sencor 75DF | Alfalfa | Postemergence | 1 to 1⅓ lb | May be applied postdormant but prior to 3 in. of alfalfa top growth when impregnated on dry fertilizer. |
| Sinbar 80W | Alfalfa only | Dormant | ½ to 1½ lb | Apply once in the fall or spring before new growth starts. Use lower rates for coarser soils. Do not use on sandy soils with less than 1% organic matter, as severe injury may result. Do not plant any crop for 2 years after application. |
| Treflan HFP<br>TR-10 | Alfalfa | Dormant or after a cutting during the growing season | 4 pt (HFP)<br>20 lb (TR-10) | A single rainfall or overhead-sprinkler irrigation of 0.5 in. or more, flood irrigation, or furrow irrigation after application is required to activate the herbicide. If activation does not occur within 3 days after application, incorporate using equipment that provides thorough soil mixing with minimum damage to the established alfalfa. Treflan HFP may be surface-applied or applied by chemigation. |
| Velpar 2L<br>90SP<br>75DF | Alfalfa only | Dormant | 1 to 3 qt<br>½ to 1½ lb<br>⅓ to 2 lb | Apply in the fall or spring before new growth exceeds 2 in. in height. May also be applied to stubble after hay crop removal but before regrowth exceeds 2 in. Do not plant any crop except corn or root crops within 2 years of treatment. Corn may be planted 12 months after treatment, provided that the use rate did not exceed 3 pt per acre, except in areas of low rainfall (20 in. or less). |

**Table 11. Herbicides used in forage legumes and restrictions**

| Herbicide name | | Applied on / at | | Days before use | |
|---|---|---|---|---|---|
| Trade | Common | Forage[a] | When[a] | Graze | Hay |
| **Seedling legumes** | | | | | |
| Balan | benefin | AL, CL, BT | PPI | 0 | 0 |
| Buctril | bromoxynil | AL | Postfall | 60 | 60 |
| | | AL | Postspring | 30 | 30 |
| Butyrac 200 or Butoxone 200 | 2,4-DB | AL, CL, BT | Post | 60 | 60 |
| | | AL only | | | |
| Eptam | EPTC | AL, CL, BT | PPI | ...[b] | ...[b] |
| Gramoxone Max | paraquat | AL | After cut[c] | 30 | 30 |
| Poast Plus | sethoxydim | AL | Post | 7 | 14 |
| | | CL | Post | 20 | 20 |
| Pursuit | imazethapyr | AL | Post | 30 | 30 |
| Raptor | imazamox | AL | Post | 20 | 20 |
| Select | clethodim | AL, BT | Post | 15 | 15 |
| Treflan | trifluralin | AL | PPI | 21 | 21 |
| **Established legumes** | | | | | |
| Gramoxone Max | paraquat | AL | Post | 30 | 30 |
| Gramoxone Max | paraquat | AL | Dormant | 42 | 42 |
| Many | 2,4-D | AL | Post | 30 | 30 |
| Many (Table 2) | glyphosate | AL | Post | 14 | 14 |
| Many (Table 2) | glyphosate | AL | Spot treat | 56 | 56 |
| Many (Table 2) | glyphosate | AL, CL, BT | Renovate | 7 | 7 |
| Poast Plus | sethoxydim | AL, CL, BT | Last cutting | 7 | 14 |
| Pursuit | imazethapyr | AL | After cut[c] | 30 | 30 |
| Raptor | imazamox | AL | Post | 20 | 20 |
| Select | clethodim | AL, BT | Post | 15 | 15 |
| Sencor | metribuzin | AL | Dormant | 28 | 28 |
| Sencor | metribuzin | AL | Predormant / postdormant[d] | 60 | 60 |
| Sinbar | terbacil | AL | Dormant | ...[b] | ...[b] |
| Treflan | trifluralin | AL | Dormant or after cutting | 21 | 21 |
| Velpar | hexazinone | AL | Dormant | 30 | 30 |

[a]AL = alfalfa, CL = clover (red, alsike, or ladino), BT = birdsfoot trefoil, PPI = preplant incorporated.
[b]No grazing information on label.
[c]Between cuttings (fewer than 5 days after cut, with less than 2 in. regrowth).
[d]If impregnated on dry fertilizer.

spring. Unless they are unusually dense or production of weed seed becomes a concern, these weeds may not be a significant problem. Some weeds such as dandelions are palatable and may not require control if the overall legume stand is dense and healthy, but undesirable weeds must be controlled early to prevent their establishment.

## Postemergence Herbicides

**Poast Plus** (sethoxydim) or **Select** (clethodim) may be applied to seedling alfalfa for control of annual and some perennial grass weeds after weed emergence. Grasses are more easily controlled when small. **Butyrac** (2,4-DB) controls many broadleaf weeds and may be applied postemergence in many seedling forage legumes. **Pursuit** (imazethapyr) or **Raptor** (imazamox) may be applied postemergence to seedling alfalfa for control of several broadleaf and grass weed species. **Buctril** (bromoxynil) may be used to control broadleaf weeds in seedling alfalfa. Be sure to apply Buctril while weeds are small, and use precautions to avoid an adverse effect on the crop. (See Table 9 for specific weed-control ratings and Table 10 for rates and remarks.)

### Established Legumes

The best weed-control practice in established forage legumes is maintenance of a dense, healthy stand with proper management techniques. Chemical weed control in established forage legumes is often limited to late-fall or early-spring applications of herbicide. **Sencor** (metribuzin), **Sinbar** (terbacil), and **Velpar** (hexazinone) are applied after the last cutting in the fall or in the early spring. These herbicides control many broadleaf weeds and some grasses, too. The herbicide **2,4-DB** controls many broadleaf weeds in established alfalfa; it should be applied when the weeds are small and actively growing. **Pursuit** or **Raptor** may be applied postemergence to established alfalfa stands to control certain broadleaf and grass weed species. Refer to Tables 9 and 10 for additional remarks and weed-control suggestions.

Once grass weeds have emerged, they are particularly difficult to control in established alfalfa. **Poast Plus** or **Select** may be used in established alfalfa for postemergence control of annual and some perennial grasses. Optimal grass control is achieved if applications are made when grasses are small and before the weeds are mowed.

Table 10 outlines current suggestions for weed-control options in legume forages. The degree of control often varies with weed size, application rate, and environmental conditions. Select the correct herbicide for the specific weeds to be controlled (Table 9). Refer to Table 11 for grazing and harvesting restrictions for forage legumes. Always consult the herbicide label for specific information about using a given product.

## Recommended Web Resources

**http://www.cdms.net**
This is an excellent index of chemical companies involved in agriculture that is searchable by product (trade name). It contains links to the companies' Web sites and is a good resource for obtaining current product label recommendations.

**http://www.greenbook.net**
This Web site contains extensive information on pesticides, including current pesticide labels and material safety data sheets.

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# 4

# Plant Disease Management for Field Crops

Yield and quality of field crops in Illinois are affected by disease each year. The damage from crop diseases can be minimized by implementing optimal management practices. Disease-management programs should use integrated disease-control measures that focus on the specific diseases known to occur in a particular area. Disease-management tactics include using resistant or tolerant crop varieties, crop rotations, fungicides, and appropriate agronomic practices. This chapter emphasizes information on fungicides, which in most cases should be used only in conjunction with or after other disease-control measures have been implemented.

The success of disease-control measures may depend on how carefully crops are scouted and how accurately the disease is diagnosed. Periodic scouting increases the likelihood that disease controls will be applied properly and at the time when they are most effective, and it can help prevent economic loss from disease and unnecessary use of pesticides.

Additional information for the management of important diseases of corn, soybeans, wheat, and alfalfa can be found in Table 1 and in the following issues of *Report on Plant Disease (RPD):* no. 123, "Winter Wheat Disease Management Program"; no. 212, "Illinois Corn Disease Management Program"; no. 308, "Alfalfa Disease Management Program"; no. 507, "Illinois Soybean Disease Management Program"; and no. 1002, "Characteristics of Fungicides Used in Field Crops." These and other issues of *RPD* on specific diseases are available from the Department of Crop Sciences, University of Illinois, N-533 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801. The cost per report is $1. Most of the *RPD* issues are also now available on the Web at http://www.ag.uiuc.edu/~vista/pubs.html.

## Disease Diagnosis

Accurate diagnosis of a disease is a critical initial step for successful disease management. Several different diseases or other plant health problems cause similar symptoms on plants, and an accurate diagnosis is required to choose the best disease-control measures. Many pesticides have specific activity against only certain types of pests, and their incorrect use wastes time and money. Diligent efforts should be made to ensure that diseases are diagnosed accurately. Plants should be collected for diagnosis as soon as disease symptoms are noted. It can be very difficult to accurately diagnose a disease after the plants are dead and dry. The University of Illinois can help with disease diagnosis. Samples can be sent to the Plant Clinic in Urbana for a thorough diagnosis; call (217)333-0519, or visit the Web site at http://plantclinic.cropsci.uiuc.edu/. Samples can also be taken to a University of Illinois Extension office to use the Distance Digital Diagnosis System.

## Always Read the Label Before Using a Pesticide

The pesticide names used in this publication include both the common, or coined, chemical names and representative trade names. The *common name* is the active ingredient (for example, metalaxyl) and is not capitalized. The *trade name* is a specific company's product name and is capitalized (for example, Allegiance FL). Often, multiple trade names exist for products containing the same active ingredient. In such cases, the specific company product names have been replaced by the term *many*. Different product combinations and formulas are frequently available.

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

Consult your local agrichemical dealer or Extension office for additional information. **Before making any pesticide-application decisions, refer to the most recent product label for application rates, days to harvest, and other information.** The information on a pesticide label can change at any time and may have changed since this chapter was published.

According to the Illinois Pesticide Act, a license is required for anyone who purchases or applies restricted use pesticides. These products clearly state the words "restricted use" on the label. In addition, anyone applying general use pesticides in the course of employment must have a license. See Chapter 16 for more information about licensing requirements for pesticide application in Illinois.

## Fungicide Guidelines

### Common Fungicide Terms

A variety of terms is used to describe the mobility and activity of fungicides. Examples include protective-contact, local penetrant, local systemic, translocated, preventive, and curative. Further characterization of the fungicides is shown in Table 3.

**Protective-contact fungicides.** These products remain on the surface of plant foliage, protecting it from infection for some period. They do not enter the plant tissue. Uniform spray coverage is vital. The length of protection depends on many factors. As with any pesticide, either rainfall or irrigation within a few hours after application may wash away much of the pesticide and greatly reduce the protective value. Even after drying on the plant surface, residues continue to be eroded via rain, dew, vaporization, sunlight, etc., thus reducing protection. Furthermore, as the plant tissues expand or are replaced, new tissue is left unprotected. For these reasons, protective-contact fungicides must be reapplied more often than systemic fungicides. The addition of a spreader-sticker adjuvant to the spray mix may help improve coverage and slow residue loss. As always, carefully read both the fungicide and the adjuvant label to ensure that the proposed tank mix is legal and safe for the crop.

**Local penetrant and systemic fungicides.** These products are absorbed into the plant. Some are fairly mobile within the plant, while others are not. Local penetrant (sometimes called local systemic) fungicides are absorbed into the immediate area of application but are not translocated far from the site of uptake. They serve to prevent the development of disease at and near the site of absorption. Systemic fungicides are more mobile than local penetrants. However, the systemic fungicides currently available in the field-crops market display only upward/outward mobility in the plant. This upward/outward movement is sometimes referred to as acropetal or apoplastic translocation.

**Curative vs. preventive activity.** Fungicides can also be classified according to *when* they act upon the pathogen. Preventive fungicides prevent the infection and establishment of the pathogen. All fungicides offer some degree of preventive activity. Because protective-contact fungicides do not enter the plant, it stands to reason that they provide only preventive activity.

Some systemic and local penetrant fungicides have "curative" properties, meaning the fungicide has the ability to stop the progress of infections that may have occurred a few hours or days before the application. This "kick-back" or "reach-back" characteristic is useful when responding to infection episodes. However, the effectiveness of even curative fungicides is diminished when an applicator waits too long and disease severity becomes too high.

### Seed Treatments

The greatest benefits of fungicide seed treatments are often found where seed is of low quality due to damage or fungal infestation, where the seedbed is sufficiently cool and wet to delay germination or emergence, and where low seeding rates are used. Fungicide seed treatments are not a substitute for high-quality seed and do not improve the performance of seed that is low in quality due to mechanical damage or physiological factors. Treated seed of low quality usually does not produce stands or yields equal to untreated high-quality seed. Therefore, only seed of high quality should be considered first for planting.

The checklist for soybean seed treatments (Table 4) is designed to assist in determining the need for seed treatments, especially for control of damping-off pathogens. Selection of the proper seed treatment is very important because certain fungicides may be effective for controlling only specific pathogens, such as *Phytophthora* and *Pythium*.

### Foliar Treatments

Foliar fungicide treatments may reduce losses due to disease in soybeans, corn, and small grains. Foliar sprays of fungicides may maintain yields and seed quality when conditions are favorable for disease development. The use of fungicides should be based on expected disease severity and is most economical for seed-production fields.

The checklist in Table 5 may be used to determine if fungicide controls for pod and stem blight, anthracnose, stem canker, Septoria brown spot, Cercospora leaf blight, or frog-eye leaf spot. If the checklist is used to determine whether disease severity warrants spraying and fungicides are applied correctly, maximal benefits should be achieved. Refer again to Table 2 for Asian soybean rust fungicide recommendations.

Foliar fungicides can be applied to corn, primarily in seed-production fields, to control leaf blights, gray leaf spot, and common and southern rust diseases. The use of fungicides is generally justified only when disease is prevalent within 1 to 2 weeks of tasseling. Infections 1 to 2 weeks after tasseling or later are generally not economically controlled with fungicides.

Foliar fungicides can be applied to small grains (primarily wheat) to control rusts, Septoria diseases, leaf blights, and tan spot. When inadequate rotations have been used and weather is wetter than normal, these diseases are most damaging from emergence of the flag leaf to early milk stage. If registered products are available, fungicides can reduce the effect of Fusarium head blight (scab) on wheat. Fungicides may increase yields and can increase both seed weight and quality. Decisions to use fungicides should be based on the amount of disease at the emergence of the flag leaf.

Spray adjuvants (surfactants) help disperse fungicides and improve coverage. If an adjuvant is compatible with the product, it can be added to the spray mix. They are especially helpful for corn and small grains.

## Disease Reactions of Field Crop Varieties Recommended for Illinois

Disease incidence and severity vary from one locality to another and from year to year depending on disease resistance in the crop, the weather and soil conditions, previous disease, and races of the pathogens present. For information on suggested disease-resistant crop varieties, consult your seed dealer; local Extension office; or the Department of Crop Sciences, University of Illinois, AW-101 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801. For soybean variety selection, disease resistance, and other information, resources are available on the Web at the Varietal Information Program for Soybeans (VIPS) site: http://web. aces.uiuc.edu/VIPS/newIndex.cfm.

## Nematicide Application

Granular nematicides/insecticides registered for use on corn and sorghum may be used as in-furrow or band treatments, depending on the product label. Follow the manufacturer's suggestions on application methods. Nematicides should be used only where soil analysis shows high numbers of parasitic nematodes above a threshold value. Follow soil-sampling instructions in *RPD* no. 1100, "Collecting and Shipping Soil Samples for Nematode Analysis." Nematicides are not designed to replace crop rotation or the use of resistant crop varieties in a management program. Successful nematode management is based upon an integrated approach that may include pesticides. Pesticides alone do not provide adequate control and may produce environmental problems.

## Recommended Web Resources

**http://www.ag.uiuc.edu/~vista/pubs.html**
Publications on agriculture and horticulture topics written by University of Illinois faculty and staff. This site contains issues of *Report on Plant Disease.*

**http://www.pesticidesafety.uiuc.edu**
Pesticide safety education, including information on pesticide applicator training and safe and effective use of pesticides.

**http://www.ipm.uiuc.edu/bulletin/index.php/**
The online *Pest Management and Crop Development Bulletin* contains pest-management information for diseases, insects, and weeds in Illinois.

**http://web.aces.uiuc.edu/VIPS/newIndex.cfm**
The Varietal Information Program for Soybeans site contains information on disease-resistance ratings, as well as other traits for soybean varieties.

**http://www.ipm.uiuc.edu/**
The University of Illinois's integrated pest management (IPM) site.

**http://cropdisease.cropsci.uiuc.edu/**
Basic information to help users recognize, understand, and manage field crop diseases in Illinois.

**http://www.apsnet.org/**
The American Phytopathological Society's Web site contains extensive information on plant diseases and their control, as well as a catalog of publications on plant diseases.

**http://www.greenbook.net**
This Web site contains much information on pesticides, including current pesticide labels and material safety data sheets.

**http://plantclinic.cropsci.uiuc.edu/**
The Web site for the University of Illinois Plant Clinic describes services offered, fees, and directions for submission of plant samples for diagnosis.

**http://soyrust.cropsci.uiuc.edu/index.cfm**
University of Illinois Department of Crop Sciences Soybean Rust Web site.

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**Table 1. Disease-control guidelines for field crops (see product labels for specific, current information)**

| Crop, disease | Fungicide or nematicide | | Comments and recommendations |
|---|---|---|---|
| | Common name | Trade name | |
| **ALFALFA** | | | |
| Seed rots and seedling blights | captan | many | Seed treatment is often helpful, even with high-quality seed. |
| | fludioxinil | Maxim XL | |
| | mefenoxam | Apron XL LS, Ridomil Gold EC | |
| | metalaxyl | Allegiance FL and LS, Apron FL | |
| | thiram | many | |
| Bacterial wilt, Fusarium wilt<br>Phytophthora root rot<br>Aphanomyces root rot | | | Resistant varieties should be planted. |
| Leaf spots, spring blackstem, and anthracnose | copper hydroxide | Kocide Champ | Cut forage in a timely manner to reduce leaf loss and maximize yield and quality. Studies have shown inconsistent benefits of using foliar fungicides. Choose varieties with resistance to anthracnose. |
| Crown and root rots | | | Maintain proper fertility and soil pH. Avoid harvesting or grazing too often during the last 5 to 6 weeks of the growing season. Control insect pests. |
| Verticillium wilt | | | This disease is most often a problem in stands that are more than 3 years old. Resistant varieties should be planted. |
| Sclerotinia crown and stem rot | | | Use the most resistant varieties, and plant in the spring. The use of 3- or 4-year rotations with nonlegume crops and deep plowing where possible may reduce disease severity. |
| **BARLEY** | | | |
| Seed rots, seedling blights, loose smut | captan | many | Seed treatment is strongly suggested. Metalaxyl and mefenoxam control only Pythium seedling blight in barley. |
| | carboxin | Vitavax | |
| | fludioxinil | Maxim XL | |
| | mefenoxam | Apron XL LS | |
| | metalaxyl | Allegiance FL and LS, Apron FL | |
| | PCNB | many | |
| | tebuconazole + thiram | Raxil-thiram | |
| | thiram | many | |
| | triadimenol | Baytan 30 | |

**Table 1. Disease-control guidelines for field crops (cont.)**

| Crop, disease | Fungicide or nematicide: Common name | Fungicide or nematicide: Trade name | Comments and recommendations |
|---|---|---|---|
| **BARLEY (CONT.)** | | | |
| Barley yellow dwarf virus | | | Plant winter barley after the Hessian fly–free date and spring barley as early as possible. |
| **CLOVER** | | | |
| Anthracnose diseases | | | Grow resistant adapted varieties. |
| Crown and root rots | | | Same as for alfalfa. |
| Seed rots, seedling blights, and Sclerotinia | | | Same as for alfalfa. |
| **CORN** | | | |
| Seed rots and seedling blights | azoxystrobin | Dynasty | Sow injury-free, plump seed in noncompacted soils that are at least 50°F. Prepare the seedbed properly and place herbicide, fertilizer, insecticide, and seed correctly. Fungicide seed treatments are commonly used. Dynasty will be applied only in combination with mefenoxam and fludioxonil. |
| | captan | many | |
| | carboxin | Vitavax | |
| | fludioxonil | Maxim 4FS | |
| | mefenoxam | Apron XL LS | |
| | metalaxyl | Allegiance | |
| | thiram | many | |
| | trifloxystrobin | Trilex | |
| Northern leaf blight<br>Southern leaf blight<br>Northern leaf spot | azoxystrobin | Quadris | Plant resistant hybrids. Chlorothalonil is registered only for seed corn and sweet corn. Begin applications when conditions favor disease development, and repeat at 4- to 7-day intervals or as required to maintain control. |
| | chlorothalonil | Bravo | |
| | mancozeb | Dithane M-45, Manzate 200, Penncozeb | |
| | propiconazole | Tilt<br>PropiMax EC | Stratego contains propiconazole and trifloxystrobin. Do not make more than 3 applications of strobilurin-containing fungicides (such as Quadris and Stratego) per crop. Also, these fungicides should be applied alternately with fungicides having different modes of action to reduce development of fungicide-resistant pathogens. |
| | propiconazole + azoxystrobin | Quilt | |
| | propiconazole + trifloxystrobin | Stratego | |
| Gray leaf spot | azoxystrobin | Quadris | Gray leaf spot is usually most damaging in no-till continuous corn. Fields located in low-lying areas or areas subject to frequent fogs, high humidity, or irrigation are prone to disease. Plant tolerant or resistant hybrids and use crop rotation and tillage where feasible. |
| | propiconazole | Tilt<br>PropiMax EC | |
| | propiconazole + azoxystrobin | Quilt | |
| | propiconazole + trifloxystrobin | Stratego | |
| Common rust and southern rust | azoxystrobin | Quadris | Same as for leaf blights and spots. Quadris and Stratego are labeled for control of common rust. Chlorothalonil is registered only for seed corn and sweet corn. |
| | chlorothalonil | Bravo | |
| | propiconazole | Tilt<br>PropiMax EC | |
| | propiconazole + azoxystrobin | Quilt | |
| | propiconazole + trifloxystrobin | Stratego | |

**Table 1. Disease-control guidelines for field crops (cont.)**

| Crop, disease | Fungicide or nematicide: Common name | Fungicide or nematicide: Trade name | Comments and recommendations |
|---|---|---|---|
| **CORN (CONT.)** | | | |
| Stewart's disease (a bacterial disease) | | | Plant resistant hybrids. Insecticides and insecticide seed treatments may be used to control flea beetles when necessary. |
| Goss's bacterial wilt and leaf blight (a bacterial disease) | | | Plant resistant hybrids. Clean plowdown and 2-year crop rotations also give control. Use clean plowdown only where erosion is not a problem. |
| Anthracnose, Physoderma brown spot, eyespot,* yellow leaf blight | azoxystrobin | Quadris | Plant resistant or tolerant hybrids. Practice crop rotation or clean tillage where soil-erosion considerations allow. Quadris is labeled for control of anthracnose leaf blight and eye spot. *Propiconazole (PropiMax and Tilt) is also labeled for eyespot. |
| Crazy top and sorghum downy mildew | | | Plant resistant or tolerant hybrids. Improve drainage in affected area. Control wild cane to reduce sorghum downy mildew inoculum. |
| Viral diseases | | | Plant resistant hybrids. Control johnsongrass to reduce overwintering source of maize dwarf mosaic and maize chlorotic dwarf viruses. |
| Stalk rots (charcoal, *Diplodia, Fusarium, Gibberella, Nigrospora,* anthracnose) | | | Plant hybrids with good stalk rot resistance and stalk strength. Maintain adequate nitrogen, phosphorus, and potassium fertility. Control corn borers and corn rootworms. Scout fields at 30 to 40% moisture for lodging potential. Walk a zigzag pattern through the field, pushing ran-random plants about 5 inches from the vertical. If more than 10 to 15% lodge, schedule the field for early harvest. |
| Storage molds *Aspergillus* spp. *Penicillium* spp. | propionic acid | | Grain treated with an acid grain preservative may be used only for animal feed. Store undamaged corn at 15 to 15.5% moisture from fall until spring, then dry to 13% for long-term storage. Grain damaged by field molds, insects, and the like should be dried to 13 to 13.5% moisture at harvest. Watch stored grain for heating, musty odor, crusting, or other signs of storage mold activity. Control stored-grain in sects. Make sure the combine is adjusted to avoid damage to grain. Remove fines and for eign material before storage. |

**Table 1. Disease-control guidelines for field crops (cont.)**

| Crop, disease | Fungicide or nematicide: Common name | Fungicide or nematicide: Trade name | Comments and recommendations |
|---|---|---|---|
| **CORN (CONT.)** | | | |
| Nematodes<br>Dagger<br>Lance<br>Ring<br>Root-knot | ethoprop<br>terbufos | Mocap<br>Counter | Use nematicidal rates of these materials only when soil tests indicate populations of nematodes are above threshold. Eliminate pH, fertil- hardpan, soil insects, and other diseases as possible limiting factors before using nematicides. |
| Root-lesion<br>Spiral<br>Sting<br>Stubby-root<br>Stunt | | | More than one genus of plant-parasitic nematode may be present in a field. Identification of nematodes should be done before selecting rotation. |
| Needle | | | Use crop rotation where appropriate. For needle nematode control, avoid small grains in rotations and control grassy weeds. |
| **OATS** | | | |
| Seed rots and seedling blights | captan<br>carboxin<br>fludioxonil<br>mefenoxam<br>metalaxyl<br><br>PCNB<br>tebuconazole + thiram<br>thiram<br>triadimenol | many<br>Vitavax<br>Maxim 4FS<br>Apron XL LS<br>Allegiance FL and LS, Apron FL<br>many<br>Raxil-thiram<br><br>many<br>Baytan 30 | Seed treatment is strongly suggested for control of smut diseases. Carboxin, PCNB, tebuconazole, and triadimenol have efficacy against smut diseases. |
| Barley yellow dwarf | | | Grow resistant varieties. Plant susceptible varieties as early in the spring as possible. |
| Rusts | propiconazole | PropiMax<br>Tilt | Plant resistant varieties. Fungicides applied for *Septoria* and *Helminthosporium* also aid in crown rust control. |
| **SORGHUM** | | | |
| Seed rots, seedling blights, and smuts | captan<br>fludioxonil<br>mancozeb<br><br><br>mefenoxam<br>PCNB<br>thiram | many<br>Maxim 4FS<br>Dithane M-45, Manzate 200, Penncozeb<br><br>Apron XL<br>many<br>many | Fungicide seed treatment is strongly suggested. Plant in soils at least 60° to 65°F. |

**Table 1. Disease-control guidelines for field crops (cont.)**

| Crop, disease | Fungicide or nematicide: Common name | Fungicide or nematicide: Trade name | Comments and recommendations |
|---|---|---|---|
| **SORGHUM (CONT.)** | | | |
| Nematodes | aldicarb<br>terbufos | Temik<br>Counter | Apply only where soil analysis indicates an economic nematode population. Eliminate pH, fertility, hardpan, soil insects, and other dis eases before using nematicides. Crop rotation may be practical only after identifying the nematodes involved. |
| **SOYBEANS** | | | |
| Seed rots and seedling blights (primarily *Fusarium, Pythium, Phytophthora,* and *Rhizoctonia)* | azoxystrobin + metalaxyl<br>*Bacillus pumilis*<br>captan<br>carboxin<br>fludioxonil<br>mefenoxam<br>metalaxyl<br>PCNB<br>thiabendazole<br>thiram | SoyGard<br>Yield Shield<br>many<br>Vitavax<br>Maxim 4FS<br>Apron XL LS<br>Allegiance FL and LS<br>many<br>TBZ<br>many | Plant high-quality seed germinating more than 70% in a cold germination test. Seed treatment is recommended when seed of unknown quality due to fungal infection must be planted, de lays in emergence are anticipated, seed is planted to produce seed, reduced seeding rates are used, or seed is planted into wet soil or heavy crop residue (reduced tillage or no-till). Plant in soils that are at least 55°F. Apron XL LS and Allegiance FL control *Pythium and Phytophthora.* |
| Charcoal rot | | | Plant full-season varieties as early as possible. Avoid excessive seeding rates and maintain optimal fertility. Deep fall plowing may be beneficialwhere soil erosion concerns allow. |
| Brown stem rot | | | Rotate, using 2 years of corn where brown stem rot has been a problem. Plant varieties labeled tolerant, resistant, or moderately resistant. Control soybean cyst nematode. |
| Sclerotinia white mold | thiophanate-methyl | Topsin-M | Rotate with nonlegume crops. Plant moderately resistant varieties in fields where disease has been present before. Burial of infected residues is recommended where white mold is a recurring problem. Tillage operations are suggested *after* the following corn crop to help conserve soybean residues. Corn is not affected by white mold. Residue burial is *not* recom mended where erosion can be a problem. Fun gicides must be directed into the lower canopy for control. Seed treatments with TBZ fungicides have been shown to reduce potential for seedborne distribution. TBZ is not labeled as a foliar treatment. |

**Table 1. Disease-control guidelines for field crops (cont.)**

| Crop, disease | Fungicide or nematicide: Common name | Fungicide or nematicide: Trade name | Comments and recommendations |
|---|---|---|---|
| **SOYBEANS (CONT.)** | | | |
| Phytophthora root rot | mefenoxam | Apron XL<br>Ridomil Gold | Plant varieties with race-specific or field resistance (tolerance). Race-specific resistance with Rps genes provides immunity to specific races. In some areas, races of the *Phytophthora* fungus are present that can attack this type of resistance. In this case, varieties with field tolerance should be planted. All varieties should be protected in the seedling stage with Apron XL LS or Allegiance FL fungicide applied as a seed treatment. |
| | metalaxyl | Allegiance | |
| Nematodes | | | |
| Soybean cyst nematode (SCN) | | | Use SCN-resistant varieties. The same resistant soybean varieties should not be grown in the same field twice. Monitor SCN populations by taking soil samples. Maintain proper soil samples. Maintain proper soil fertility. Rotate with nonhost crops, such as corn or small grains. |
| Root-lesion<br>Dagger<br>Lance<br>Root-knot<br>Spiral<br>Sting<br>Stubby-root<br>Stunt | | | No soybean varieties are resistant to root-lesion nematodes, so crop rotation and nematicides are the most practical approaches to control. |
| Sudden death syndrome (SDS) | | | Some varieties have partial resistance to SDS. Plant more than one variety where SDS has been a problem and stagger planting dates. Early-planted soybeans are frequently more severely damaged than later-planted ones. Vary maturity by planting more than one ma turity group or use different maturities within a single group. Infection is influenced by cool and wet weather. Control soybean cyst nema tode. |
| Pod and stem blight, anthracnose, stem canker, Septoria brown spot, Cercospora leaf blight, purple seed stain, frogeye leaf spot | azoxystrobin<br>chlorothalonil<br>thiophanate-methyl | Quadris<br>Bravo<br>Topsin-M | Fungicides may be warranted when conditions are favorable for these foliar diseases (see Table 3). Two applications of fungicide are suggested for maximum yield and seed quality. Use 3 applications of Bravo in areas with a history of moderate to severe disease intensity. Do not graze or feed treated soybean vines to livestock. |

**Table 1. Disease-control guidelines for field crops (cont.)**

| Crop, disease | Fungicide or nematicide: Common name | Fungicide or nematicide: Trade name | Comments and recommendations |
|---|---|---|---|
| **SOYBEANS (CONT.)** | | | |
| Asian soybean rust | azoxystrobin | Quadris | As of September 2005, Asian soybean rust has not been found in Illinois. Current state reports are found at http://www.sbrusa.net/. If Asian soybean rust is detected in Illinois, preventive and curative programs should be implemented. Producers approximately 250 miles from detection should consider preventive applications, and fields already infected or within that radius should be considered for curative programs. Yield losses will begin at < 3% infection. |
| | chlorothalonil | Bravo | |
| | | Echo 720 | |
| | | Echo 90DF | |
| | | EQUUS 720 SST | |
| | | EQUUS DF | |
| | | Weather Stik | |
| | myclobutanil | Laredo EC | |
| | | Laredo EW | |
| | pyraclostrobin | Headline | |
| | propiconizole | Bumper 41.8EC | |
| | | Propimax EC | |
| | | Tilt | |
| | tebuconazole | Folicur 3.6F | |
| | | Orius 3.6F (no label in Illinois) | |
| | tetraconazole (unregistered) | Domark 230ME | |
| | trifloxystrobin + propiconizole | Stratego | |
| | propiconizole + azoxystrobin | Quilt | |
| | pyraclostrobin + tebuconazole | Headline SBR | |
| **WHEAT** | | | |
| Seed rots, seedling blights, loose smut, and bunt (stinking smut) | captan | Captan | Seed treatment is strongly suggested. Thiram or captan alone does not control loose smut. A number of products contain various combinations of these fungicides. Many different fungicidal products are available for treatment of wheat seed, and this list is intended to provide examples of products available. |
| | carboxin | Vitavax | |
| | difenoconazole | Dividend XL | |
| | difenoconazole + mefenoxam | Dividend Extreme | |
| | fludioxinil | Maxim XL | |
| | mancozeb | Grain Guard | |
| | metalaxyl | Allegiance FL and LS, Apron FL | |
| | mefenoxam | Apron XL LS | |
| | PCNB | many | |
| | tebuconazole + thiram | Raxil-thiram | |
| | thiabendazole | TBZ | |
| | thiram | many | |
| | triadimenol | Baytan 30 | |

**Table 1. Disease-control guidelines for field crops (cont.)**

| Crop, disease | Fungicide or nematicide: Common name | Fungicide or nematicide: Trade name | Comments and recommendations |
|---|---|---|---|
| **WHEAT (CONT.)** | | | |
| Septoria leaf blotch, Stagnospora glume blotch, Helminthosporium leaf blight, Pyrenophora tanspot | azoxystrobin | Quadris | Plant resistant varieties. Apply fungicide when disease conditions warrant. Quadris is not labeled for *Helminthosporium*. |
| | mancozeb | Dithane M-45, Manzate 200, Penncozeb | |
| | propiconazole | Tilt | |
| | propiconazole + azoxystrobin | Quilt | |
| | propiconazole + trifloxystrobin | Stratego | |
| | pyraclostrobin | Headline | |
| Leaf rust, stripe and stem rust | azoxystrobin | Quadris | Product labels should be consulted for allowable number of applications and growth stage (Feekes' stage) when last application is allowed. |
| | propiconazole | Tilt | |
| | propiconazole + azoxystrobin | Quilt | |
| | propiconazole + trifloxystrobin | Stratego | |
| | pyraclostrobin | Headline | |
| | triadimenol | Baytan 30 | |
| Powdery mildew | azoxystrobin | Quadris | Plant resistant varieties. |
| | propiconazole | Tilt | |
| | propiconazole + azoxystrobin | Quilt | |
| | propiconazole + trifloxystrobin | Stratego | |
| | pyraclostrobin | Headline | |
| | triadimenol | Baytan 30 | |
| Take-all | | | Plant after the Hessian fly–free date. Use ammonium form of nitrogen fertilizer. Use crop rotations of 2 to 3 years between wheat crops where possible. |
| Fusarium head blight (scab) | | | Consult your Extension office for fungicides that may be temporarily labeled for scab managment. Chose resistant varieties, and plant varieties with different maturities. |
| Viral diseases | | | |
| Wheat streak mosaic, wheat soilborne mosaic | | | Plant resistant or tolerant varieties. Plant after the Hessian fly–free date. Control volunteer wheat in and around production fields. |
| Barley yellow dwarf, wheat spindle streak mosaic | | | Insecticide seed treatments may help reduce barley yellow dwarf virus by controlling aphids. |

**Table 2. Illinois Asian soybean rust fungicide information[a]**

| Common name | Fungicide trade name | Manufacturer | Rate/acre | Application (GPA) | Labeled no. applications | PHI (days) | Chemical class | Mode of action |
|---|---|---|---|---|---|---|---|---|
| **EPA soybean rust section 3 fungicides** | | | | | | | | |
| azoxystrobin | Quadris | Syngenta | 6.2–15.4 fl oz | adequate coverage, penetration, include COC | 1–2 | 14 | strobilurin | protectant |
| chlorothalonil | Bravo Weather Stik | Syngenta | 16–36 fl oz | 20–150, 5–10 air | 1–3 | 42 | benzonitriles | protectant |
| | Echo 720 | Sipcam Agro | 16–40 fl oz | 20–150, 5–10 air | 1–3 | 42 | | |
| | Echo 90DF | | 14–32 oz | 20–150, 5–10 air | 1–3 | 42 | | |
| | EQUUS 720 SST | Farm-saver.com | 1.37–2.25 lb | — | 3 | 42 | | |
| | EQUUS DF | | 1.25–2.2 lb | 10–20 | 3 | 42 | | |
| pyraclostrobin | Headline | BASF | 6–12 fl oz | thorough coverage of foliage | 1–2 | 21 | strobilurin | protectant |
| **EPA soybean rust section 18 fungicides (section 18s in effect until 11/10/2007)** | | | | | | | | |
| myclobutanil | Laredo EC | Dow | 4–8 fl oz | adequate coverage, penetration | 1–2 | 28 | triazole | curative |
| | Laredo EW | | 4.8–9.6 fl oz | 15–20, 5 air | 2 | 28 | | |
| propiconizole | Tilt | Syngenta | 4–8 fl oz | 15, 5 air | 1–2 | 28 | triazole | curative |
| | Bumper 41.8EC | Makhteshim-Agan | 4–8 fl oz | 15, 5 air | 1–2 | 28 | | |
| | Propimax EC | Dow AgroSciences | 4–8 fl oz | 15, 5 air | 1–2 | 28 | | |
| tebuconazole | Folicur 3.6F | Bayer | 3–4 fl oz | 10, 5 air | 1–2 | 21 | triazole | curative |
| | Orius 3.6F (no label in Illinois) | Makhteshim-Agan | 3–4 fl oz | 10, 5 air | 1–2 | 30 | | |
| tetraconazole (unregistered) | Domark 230ME | Valent | 10–13 fl oz | 20–150, 5–10 air | 1 | 21 | triazole | curative |
| trifloxystrobin + propiconizole | Stratego | Bayer | 5.5–10 fl oz | 10, 5 air | 1 | 21 | triazole + strobilurin | curative + protectant |

**Table 2. Illinois Asian soybean rust fungicide information[a] (cont.)**

| Common name | Fungicide trade name | Manufacturer | Rate/acre | Application (GPA) | Labeled no. applications | PHI (days) | Chemical class | Mode of action |
|---|---|---|---|---|---|---|---|---|
| **EPA soybean rust section 18 fungicides (section 18s in effect until 11/10/2007) (cont.)** | | | | | | | | |
| propiconizole + azoxystrobin | Quilt | Syngenta | 6.2–12 fl oz | Apply with 0.5% COC. | 1–2 | 21 | triazole + strobilurin | curative + protectant |
| pyraclostrobin + tebuconazole | Headline SBR | BASF, Bayer | 7.8 fl oz | thorough coverage, 5 air | — | 30 | triazole + strobilurin | curative + protectant |

[a]Fungicide information as of 9/19/2005. Please check the U.S. Environmental Protection Agency Web site for the most current section 3 and section 18 registrations and listing of allowed states. http://www.epa.gov/oppfead1/cb/csb_page/updates/soybean_rust.htm#section 18

**Table 3. Fungicide Resistance Action Committee (FRAC) Group, fungicide names, resistance risk, and mobility for fungicides used in Illinois field crops[a]**

| FRAC Group code and name [target site of action] | Common name | Trade name | Resistance risk | Mobility |
|---|---|---|---|---|
| 1. methyl benzimidazole carbamites [mitosis: B-tubuline assembly] | thiabendazole | LSP, in Rival | high | systemic (upward) |
| | thiophanate-methyl | Topsin-M | high | systemic (upward) |
| 3. demethylation inhibitors (DMI) [C14-demethylation in sterol biosynthesis] | difenoconazole | Dividend | medium | systemic (upward) |
| | imazalil | Flo-Pro IMZ, in Raxil MD Extra | medium (upward) | systemic |
| | myclobutanil | Laredo | medium | systemic (upward) |
| | propiconazole | Bumper, PropiMax, in Quilt, in Stratego, Tilt | medium | systemic (upward) |
| | tebuconazole | Folicur, in Gaucho XT, Orius, in Raxil | medium | systemic (upward) |
| | tebuconazole | Domark | medium | systemic (upward) |
| | triadimenol | Baytan | medium | systemic (upward) |

**Table 3. Fungicide Resistance Action Committee (FRAC) Group, fungicide names, resistance risk, and mobility for fungicides used in Illinois field crops[a] (cont.)**

| FRAC Group code and name [target site of action] | Common name | Trade names | Resistance risk | Mobility |
|---|---|---|---|---|
| 4. phenylamides [RNA polymerase I] | mefenoxam (= metalaxyl-M) | Apron XL LS, in Maxim XL, Ridomil Gold | high | systemic (upward) |
| | metalaxyl | Allegiance | high | systemic (upward) |
| 7. carboximides [complex II in fungal respiration (succinate-dehydrogenase)] | carboxin | in Prevail, Vitavax | medium | systemic (upward) |
| 11. quinone outside inhibitors (QoI) [complex III of fungal respiration: ubiquinol oxidase, Qo site in mitochondria] | azoxystrobin | Dynasty, Protégé, Quadris, in Quilt, in SoyGard | high | systemic (upward) |
| | pyraclostrobin | Headline | high | local penetrant |
| | trifloxystrobin | in Stratego, Trilex | high | local penetrant |
| 12. phenylpyrroles [MAP protein kinase in osmotic signal transduction] | fludioxonil | Maxim 4FS, in Maxim XL | low to medium | contact-protective |
| 14. aromatic hydrocarbons (chlorophenyls, nitroanilines) [lipid peroxidation (proposed)] | PCNB | in Prevail, Terra-Coat LT-2N, in Vitavax-PCNB | low to medium | contact-protective |
| M3. dithiocarbamates [multisite contact activity] | mancozeb | Dithane, Manzate, Penncozeb | low | contact-protective |
| | maneb | in Enhance Plus | low | contact-protective |
| | thiram | Thiram, in many products | low | contact-protective |
| M4. phthalimides [multisite contact activity] | captan | Captan, in many products | low | contact-protective |
| M5. chloronitriles (phthalonitriles) [multisite contact activity] | chlorothalonil | Bravo, Echo, Equus | low | contact-protective |

[a]Fungicide labels change frequently; check product labels and consult with manufacturers for current registration and crop use information.

**Table 4. Soybean seed-treatment checklist for reducing early-season stand losses due to damping-off**

| Risk factor | Points for *yes* |
|---|---|
| Rainfall for the 7-day period before planting | |
| Below normal | 2 |
| Normal | 1 |
| Above normal | 4 |
| Seedbed preparation | |
| Conventional tillage | 1 |
| Rough surface (conservation tillage) | 2 |
| No-till | 4 |
| Germination at time of planting is less than 85% in a warm test or less than 70% in a cold test (discard such seed if at all possible) | 3 |
| Previous soybean stand in field was reduced by damping-off | 4 |
| Level of resistance to Phytophthora root rot | |
| Susceptible | 3 |
| Tolerant | 4 |
| Resistant to one or more races | 1 |
| Expected rainfall for 6 days following planting | |
| Below normal | 1 |
| Normal | 1 |
| Above normal | 3 |
| Low areas of field remain flooded for 48 hours following 1 inch of rainfall | 4 |
| Seeding rate is less than 55 lb per acre | 3 |
| Field is planted to double-crop soybeans | 3 |

*Your total score:*_____

< 7 points: Seed treatment probably will not be beneficial.
7–15 points: Seed treatment may be beneficial if weather conditions do not favor rapid germination and growth.
> 15 points: Seed treatment will be beneficial to stand development.

**Table 5. Checklist to determine if foliar diseases may be a problem in soybeans and if foliar fungicides should be considered**

| Risk factor | Points for *yes* |
|---|---|
| Rainfall, dew, and humidity up to early bloom and pod set | |
| Below normal | 0 |
| Normal | 2 |
| Above normal | 4 |
| Soybeans were grown in the field last year | 3 |
| Chisel-plow, disk, or no-till was used | 1 |
| Pycnidia (black specks) are visible on more than two-thirds of brown, fallen petioles, and Septoria brown spot is obvious on the lower leaves | 2 |
| Early-maturing variety (not full-season) | 2 |
| Soybeans are to be used or sold for seed | 6 |
| Yield potential is better than 35 bushels per acre | 2 |
| Seed quality at planting time is less than 85% germination in a warm test | 1 |
| Other conditions favor disease development (weather forecast with a 30-day period of greater-than-normal rainfall and a field history of disease) | 3 |

*Your total score:* _____

For a total score of 15 or more, uncontrolled disease may decrease yields and lower seed quality.

# 5

# Insect Pest Management for Stored Grain

## Update for 2006

Registration of stored-grain insecticides changed a bit in 2005, and more changes are anticipated for 2006. Here are some key uses to note and to look for in 2006.

- Actellic 5E remains registered as the key protectant insecticide for use on stored corn as an admixture during binning or a topdress application to the grain surface. Other insecticides that can be used on stored corn in a similar manner include Diacon II and products containing diatomaceous earth or *Bacillus thuringiensis*. Additionally, a 6 percent malathion dust remains registered and available for purchase for use on stored corn. See the text and table in this chapter for details.
- Because new products with international approval have been registered for use on stored wheat and other small grains, Reldan 4E's use will be phased out. For 2006, it remains registered and available for purchase for application to barley, oats, rice, sorghum, and wheat and as an empty-bin spray for structures used to hold these grains.
- Storcide, a product containing chlorpyrifos-methyl (the active ingredient in Reldan) and the pyrethroid cyfluthrin, has been withdrawn from the market and replaced with Storcide II.
- Storcide II is a product that contains chlorpyrifos-methyl and deltamethrin, a pyrethroid for which international Codex MRLs (maximum residue limits, roughly the same as tolerances) have been established on certain grains. Storcide II is labeled for use on the same small grains currently listed on the Reldan label.
- Market availability of an insecticide containing the active ingredient spinosad is anticipated in 2006. Look for news on this insecticide as the season progresses.
- The only malathion product labeled for direct use on small grains and still available for purchase is a 6 percent dust. Its label allows use on corn, barley, oats, rice, rye, sorghum, sunflower seeds, and wheat.
- Relatively new fumigants that are labeled for use in grain storages include $ECO_2$fume, which is a mixture of 2 percent phospine gas in carbon dioxide, and ProFume, which is the fumigant gas sulfuryl fluoride. These fumigants are not designed for use by farmer applicators but instead by professional fumigators.

## Introduction

Grains produced in Illinois may be stored for periods of a few weeks to a few years before they are fed or processed. The profitability of such storage depends not only upon marketing concerns but also upon maintaining grain quality. The harvest and storage of grain do not signal an end to the possibility of losses caused by insects and pathogens.

Successful management of stored-grain insects is possible only when proper storage practices are implemented. Insecticides and fumigants should be viewed as supplements to, not replacements for, sound storage methods. When used properly, insecticides and

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

fumigants limit insect losses in stored grains without endangering the pesticide applicator or resulting in excessive pesticide residues that threaten the health of consumers (livestock or humans) of treated grain or grain products.

This chapter provides recommendations for cultural and chemical control of stored-grain insects. It is revised annually; always use the current year's handbook. Changes in registration that occur between revisions will be announced to appropriate media sources and to Extension offices.

## Developing an Insect-Management Program for Stored Grain

If grain will be stored on the farm, one goal should be to keep it relatively insect-free, preferably without using insecticides or fumigants. Taking steps to prevent a buildup of insect numbers requires time and planning, but the outcome is grain that is not infested with insects and will not be docked.

The following insect-management tactics should be considered for *preventing* infestations of insects in stored grains. If successful management is achieved with these tactics, fumigation of grain can be avoided.

- Sanitation (cleanup of old grain and grain debris)
- Empty-bin spray with an insecticide
- Empty-bin fumigation, primarily to control insects in the subfloor plenum
- Storing clean, dry grain
- Treating grain with a protectant insecticide
- Aeration to cool the grain to prevent insect feeding and reproduction
- Regular measurement of grain temperature and sampling for insects

If fall-harvested crops (corn, soybeans, and grain sorghum) are to be removed from storage by May or June the year after harvest, the nonchemical tactics listed above should be adequate to prevent infestation by stored-grain insects. Empty-bin sprays, empty-bin fumigation, and protectant insecticides probably will not be necessary.

Because wheat is harvested in midsummer, when warm temperatures enable insects to develop and reproduce rapidly, it is more vulnerable to insect infestation. However, if wheat will not be stored for more than one month, the probability for a significant buildup of stored-grain insects is relatively low, so nonchemical management tactics should be sufficient.

All grains stored long term probably will become infested with stored-grain insects. However, implementing an insect-prevention program using the tactics previously listed should lower the probability and intensity of infestation. If an insect infestation develops and fumigation becomes necessary, we recommend employing a professional fumigator. The legal and safety requirements for fumigating stored grain make the expense and risk more than most farmers are prepared to accept.

## Using Insecticides and Fumigants

The USEPA has designated certain pesticides for "restricted" use. The fumigants aluminum phosphide (alone or in combination with carbon dioxide), sulfuryl fluoride, and chloropicrin are restricted use pesticides. *Commercial* applicators must be certified to apply restricted use pesticides. Elevator employees responsible for grain treatment at their place of employment must be certified under the category Grain Facility Pest Control Applicator. Commercial fumigation professionals who treat stored grain or grain products at farms, elevators, or warehouses must be certified by the Illinois Department of Public Health. A *private* applicator who wishes to purchase or apply restricted use pesticides "for the purpose of protecting any agricultural commodity on property owned or rented by him or as exchange labor (no compensation) on the property of another" must obtain certification by passing an examination administered by the Illinois Department of Agriculture. *Regulations enacted by the Illinois Department of Agriculture mandate that private applicators must obtain special certification to purchase and apply grain fumigants.* ***To obtain certification for fumigant application, individuals must first pass the private applicator exam and then pass a grain storage and fumigation exam.*** For information about training materials, contact Bruce Paulsrud in the Department of Crop Sciences, S-420 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801, (217)244-9646.

Persons who apply pesticides should be aware that the applicator is always responsible for the results of pesticide applications. To avoid accidents and maximize the effectiveness of any application, always read the pesticide label and follow all directions and safety precautions. Be sure that the pesticide is specifically labeled for the pest, site, and application method planned. *The label is the law.*

## Insects Attacking Stored Grain

Several types of insects inhabit stored grain. Identification is often difficult because most stored-grain pests are small (1/16 to 1/4 inch long), and many species are similar in appearance. Information about identifying the many species of stored-grain insects is not presented here; see instead the reference list at the end of

this chapter. It is important, however, to recognize the different groups of insects that live in stored grains because management considerations may differ according to the insects' characteristics and behavior. Different species vary significantly in their potential to cause economic damage, and some insects cause no damage to stored grain.

#### Weevils and Other Insects That Feed Inside Kernels

Primary insect pests of stored grain develop within grain kernels and can destroy whole, sound grain. Adults deposit eggs on or in whole kernels, and larvae develop inside the kernels. Feeding by these insects causes grain to be classified as sample grade.

The primary pests found in stored grain in Illinois are the weevils—rice weevil, maize weevil, and granary weevil. The grain weevils are small (between 1/16 and 1/8 inch long) but recognizable as a group because the head projects forward as a prolonged snout. Another primary pest found in wheat, but only rarely in corn, is the lesser grain borer. The adult's head projects downward, not forward, and does not bear a snout. These insects may be found in any portion of the grain mass within a bin.

The Angoumois grain moth lays its eggs on grain kernels, and the larvae bore into the kernels and feed there. Although this insect may attack grain before harvest, most of the damage occurs in stored grain. Infestations in storage are limited to the surface of the grain mass. However, this insect only infrequently infests stored grains in Illinois.

#### Beetles That Develop and Feed Outside Grain Kernels

Most insects commonly collected in stored grain in Illinois are beetles that range in size from 1/16 inch to more than 1/2 inch long. Adults of most species are red–brown to black, and their forewings are hardened to form a "shell" over the body. Larvae of common species are cylindrical and cream colored; some bear fine hairs. Species frequently collected in Illinois grain bins include the sawtoothed grain beetle, flat grain beetle, rusty grain beetle, foreign grain beetle, hairy fungus beetle, larger black flour beetle, red flour beetle, and confused flour beetle.

Like the weevils, beetles that feed and develop outside grain kernels may inhabit any portion of a grain mass. They feed on bits and fragments of several different grains; their buildup usually results from an abundance of broken kernels (fine material) or fungal growth on moist grain. Their dependence on fines or fungal growth accounts for the description of these insects as secondary pests, "bran bugs," or "fungus feeders."

#### Surface-Feeding Caterpillars

Most caterpillars that feed in stored grain inhabit primarily the outer portions of the grain mass (usually the grain surface, but also the bottom of the mass just above perforated drying floors or aeration ducts). These caterpillars are cream colored and about 1/2 inch long when mature. They produce fine, silken webbing as they move about near the grain surface. Mature larvae pupate within a silky cocoon. Adult moths fly and mate in the bin headspace, where they may be seen resting on the bin walls and roof.

The Indianmeal moth is the most common surface-feeding caterpillar in stored grain in Illinois. The larvae may web over the grain surface completely, thus preventing proper aeration or fumigation. The adult Indianmeal moth has a wingspan of about 3/4 inch; the outer half of each front wing is red–brown or copper colored. Malathion resistance seems to be common in Illinois populations of Indianmeal moth. Other surface-feeding caterpillars include the Angoumois grain moth (which feeds within kernels), the Mediterranean flour moth, and the meal moth.

#### Other Stored-Grain Insects

Other pests that sometimes infest stored grains include psocids (booklice) and grain mites. These soft-bodied pests feed on fungi. An abundance of psocids or grain mites often indicates a more important problem of mold-related deterioration of the grain.

Not all insects in grain are pests. Parasitic wasps, larvae of a predaceous fly species, and predaceous Hemipterans (true bugs) attack certain grain pests. In addition, many field insects, such as European corn borers and sap beetles, are transported inadvertently to grain bins, where they cause no damage.

### Preventing Insect Infestations

#### Sources of Infestations

Most infestations of stored-grain insects originate from immigration of the insects into the bin from outside. All species of stored-grain insects have numerous food sources on which they survive when stored products are not available. However, large amounts of stored grain are attractive to these pests, and they invade the bins through any available opening.

Other common sources of stored-grain insects are old grain, grain spills, feeds, seed, and grain debris. Insects often move to new grain from carryover grain, from grain not cleaned from "empty" bins, from feed-supply buildings, and from grain debris beneath perforated bin floors.

Some stored-grain insects infest maturing grain in the field. Although some field infestations probably occur in Illinois, the extent of field-originated storage problems is minor.

### Sanitation

To minimize the movement of insects from old grain and grain debris to new grain, thorough cleanup is necessary. At least 2 weeks before storing new grain, clean all grain and grain debris from within and around grain bins. Be thorough; sweep or vacuum bin floors and remove and feed or destroy any grain and grain debris in combines, wagons, and augers. If grain debris is not removed from the combine, collect and feed or destroy the first few bushels of grain that pass through the combine.

### Bin Sprays

Insects may remain in certain bin locations even after a thorough cleanup. Hard-to-clean sites that harbor insect pests include cracks and crevices in bin walls and the plenum beneath nonremovable perforated floors. Consequently, application of a residual insecticide should help eliminate lingering infestations of stored-grain insects. Residual sprays also create a barrier for insects that may migrate into a storage area from outside. Applying an insecticide or a fumigant in an empty bin can supplement (but not replace) physical cleanup efforts.

Apply an insecticide to the walls, ceiling, roof, and floor of all bins that will be used to store grain for more than a few weeks during warm weather. The best time to apply a residual spray is 2 to 3 weeks before new grain will be stored in the bin. Use one of the following products:

- ½ pint of Reldan 4E (chlorpyrifos-methyl) in 3 gallons of water at a rate of l gallon per 650 to 1,250 square feet. *Do not apply Reldan to bins that will be used to store corn or soybeans.*
- 8 milliliters of Tempo 2E (cyfluthrin) per 1,000 square feet in sufficient water to cover the area being treated but not to allow dripping or runoff to occur (see product label). *Do not apply directly to grain.*
- 1.8 fluid ounces of Storcide II (a combination of the active ingredients chlorpyrifos-methyl and deltamethrin) per gallon of water. Apply 1 gallon of spray mixture per 1,000 square feet of bin wall or floor surface. Do not apply Storcide II to bins that will be used to store corn or soybeans.
- diatomaceous earth (see product label for application rate of the formulation to be used).

Unless labels specify otherwise, spray all bin surfaces to the point of runoff and be sure to treat all cracks and crevices and areas around doors thoroughly. Note and follow all label directions for application methods, protective equipment, and reentry.

### Filling the Bin

Effective insect management in stored grain requires good storage practices. Use a grain cleaner to minimize the amount of fine material that is binned with the grain. Many species of stored-grain insects cannot survive in the absence of broken kernels and grain debris. Use of a grain spreader evenly distributes remaining fine material and helps to level the grain surface. After the bin is full, if fine material is concentrated in a central core beneath the auger spout, removing one or a few loads from the bin will extract this core of fines. Periodic removal of the center core during the bin-filling process is even more effective for extracting fines. Do not add new grain on top of old because insects will move from the infested grain to the new grain. Do not overfill bins; the leveled grain surface should be at least a few inches below the lip of the bin. Leveling the grain surface is important for uniform air flow and for effective application of insecticide or fumigant.

Store only dry grain. Maintaining moisture levels that prevent the growth of storage fungi is sufficient where fall-harvested grain is to be stored only through the winter. *Wheat that will be stored 1 month or longer during warm summer weather should be dried to 12 to 13 percent moisture; corn should be dried to 14 to 15 percent moisture.*

Aerate to cool stored grain as soon as possible. Temperatures below 50°F prevent insect feeding and reproduction. Cooling grain to just above freezing kills some stages of many grain insects. Aeration also results in uniform temperatures that prevent moisture migration problems within a bin. Most grain-storage references recommend aerating to maintain grain temperatures within 15°F of average outdoor temperatures. These references usually discourage the use of aeration to cool grain below freezing.

## Grain Protectants

Application of insecticides directly to grain to prevent infestation may be warranted if grain is to be stored for more than 3 to 6 weeks at grain temperatures above 60° to 70°F. Summer-harvested grains that will be stored 1 month or longer and fall-harvested grains that will remain in storage beyond May or June of the year after harvest should be treated with a protectant insecticide. Incorporating a surface treatment is adequate for short-term protection. However, uniform application to all grain at the auger is necessary for long-term protection. If grain-protectant insecticides are applied at labeled rates, grain may be processed or fed to livestock with no waiting period.

To protect against stored-grain beetles and weevils throughout the entire mass of grain within a bin, apply a protectant insecticide to grain as it is augered

into the bin. Spray-on applicators may be mounted on the auger to apply liquid formulations. Dusts may be spread over a load of grain in a truck or wagon just before unloading. Protectant insecticides should not be applied to grain before high-temperature drying. A "topdress" or "cap-off" treatment may be used to give some control of insects entering the top of the grain mass. Table 1 summarizes the uses for registered grain protectants.

Crop-specific recommendations for the use of protectant insecticides are described in the subsequent sections.

### Corn

It is not necessary to apply any insecticide to new-crop corn that will be removed from storage by May or June of the following spring. Similarly, if corn will be used on-site as livestock feed (and not subject to grading associated with sale) within 1 year of harvest, a protectant insecticide usually is not necessary. For storage periods of 1 year or longer, apply Actellic at the loading auger, using rates listed in Table 1. *Reldan is not registered for use on corn.* Do not apply insecticides before high-temperature drying because extreme heat results in rapid volatilization of the insecticide and reduction in residues. For Actellic residues to persist on corn at effective levels through the summer after harvest, corn must be dried to approximately 14 to 15 percent moisture.

If the grain mass is not treated, surface topdressing or cap-off applications of protectant insecticides are effective against insects that feed at the grain surface. Actellic, *Bacillus thuringiensis (Bt)*, Diacon II, and diatomaceous earth may be applied to corn and incorporated into the top 4 to 6 inches of the grain mass by raking. Actellic, Diacon II, and diatomaceous earth are labeled for use against all the insects that infest stored grain; Bt products are effective against Indianmeal moth larvae. Dichlorvos resin strips may be hung in the bin headspace as a further deterrent to Indianmeal moth infestation. See the text on pages 149 and 151 regarding Diacon II and diatomaceous earth.

Long-term storage programs usually allow "rotating" corn in storage—shipping out old corn and replacing it with the new crop each year. Annual rotation of stored corn helps avoid buildup of insect infestations. Where annual rotation is practiced, topdress treatments of *Bt* (for Indianmeal moth) or Actellic applied in April or May usually provide adequate control without treating the entire grain mass.

### Soybeans

Only the Indianmeal moth infests soybeans stored at moisture levels that prevent mold growth. To protect against Indianmeal moth infestation, rake in surface applications of *Bt* or diatomaceous earth after the bin is filled and leveled or by May of the following year. Dichlorvos resin strips may be hung in the bin headspace as a further deterrent to Indianmeal moth infestation. *No other protectant insecticides are registered for application to stored soybeans.*

### Wheat

Wheat is especially vulnerable to insect infestation because it is harvested in midsummer when stored-product insects are active within and outside storage facilities. Warm temperatures in summer-harvested wheat also contribute to the rapid development and reproduction of insects within bins.

Apply Reldan or Storcide II at the loading auger to all wheat that is to be stored for 1 month or more. Reldan controls Indianmeal moth, as well as the weevils and secondary beetles that infest grain. Reldan is not effective against the lesser grain borer. Storcide II is effective against all of these pests, including lesser grain borer.

### Sorghum

For storage periods of 1 year or longer, apply Actellic, Storcide II, or Reldan at the loading auger, but not before high-temperature drying. Actellic and Reldan should persist for 12 months or more on sorghum at 12 to 13 percent moisture. Use dichlorvos resin strips or rake in surface applications of *Bt* or diatomaceous earth after the bin is filled and leveled or by May to control Indianmeal moth if the grain mass is not otherwise treated. Topdress applications of Actellic usually will provide adequate protection for one summer's storage if application is made by April or May.

### Insecticide Resistance in Stored Grain

Insecticide resistance is an important worldwide problem that is especially common (on an international scale) in stored-product insects. In Illinois, resistance to malathion is widespread among Indianmeal moth populations. Some Illinois populations of the red flour beetle are resistant to malathion, but the range and intensity of this resistance problem are not well known. Populations of the hairy fungus beetle collected in northern Illinois are resistant to both Actellic and malathion; the geographical range of resistant populations of this species is not known.

### Diacon II and Diatomaceous Earth

Diacon II contains the insect-growth regulator methoprene. It prevents the normal growth and maturation of immature insects, killing them before they become adults. It does not kill adult insects and, therefore, may not be as effective as needed in many circumstances.

**Table 1. Insecticides registered for use to protect stored grain**

Grains treated with protectant insecticides at labeled rates may be fed to livestock or processed for feed or food uses with no waiting period.

| Insecticide | Registered for use on | Rate (per 1,000 bu) | Restrictions, comments |
|---|---|---|---|
| *Bacillus thuringiensis* (many trade names) | Barley, corn, oats, rye, sorghum, soybeans, sunflower, wheat | Rate depends upon the product formulation and concentration. Follow label directions for the product in use. | These products control only the larval stage of Indianmeal moths; they must be ingested by the larvae. Apply to the top 4 to 6 inches of grain as it is augered into the bin or incorporate by raking after the bin is filled. |
| Chlorpyrifos-methyl (Reldan 4E) | Barley, oats, sorghum, wheat | Apply 9.2 fl oz on barley; 6.2 fl oz on oats; 10.7 fl oz on sorghum; 11.5 fl oz on wheat. Apply in 5 gallons of water per 1,000 bu. | Do not apply to corn or soybeans. Do not apply before high-temperature drying.<br><br>Controls weevils, secondary beetles, and Indianmeal moth. Not effective against lesser grain borer. Dry grain to 12 to 13% moisture for chlorpyrifos-methyl to persist for 1 year or longer. |
| Deltamethrin plus chlorpyrifos-methyl (Storcide II) | Barley, oats, rice, sorghum, wheat | 6.6 to 12.4 fl oz in 5 gallons water per 1,000 bu. See product label for rates for individual commodities. | Controls weevils, lesser grain borer, secondary beetles, and Indiannmeal moth. Dry grain to 12 to 13% moisture for residues to remain effective for 1 year or longer. |
| Methoprene (Diacon II) | Barley, corn, oats, wheat, sorghum | Apply 0.8 to 7.7 fl oz of formulated product in 5 gallons of water per 1,000 bu. See product label for a tabular listing of dilutions. | Do not apply to soybeans. Methoprene prevents growth and development of immature insects but will not kill adults. |
| Diatomaceous earth (several trade names) | Barley, corn, oats, rye, sorghum, wheat | Rate depends upon the product formulation and concentration. Follow label directions for the product in use. | See text. |
| Dichlorvos resin strips (DDVP, Vapona) | Barley, corn, oats, rye, sorghum, soybeans, sunflower, wheat | Hang one strip per 1,000 cu ft of bin headspace. | Dichlorvos strips release a vapor that kills adult Indianmeal moths before they reproduce and lay eggs. |

**Table 1. Insecticides registered for use to protect stored grain (cont.)**

| Insecticide | Registered for use on | Rate (per 1,000 bu) | Restrictions, comments |
|---|---|---|---|
| Pirimiphos-methyl (Actellic 5E) | Corn (including popcorn), sorghum | Apply 8.6 to 11.5 fl oz of Actellic in 5 gallons of water per 1,000 bu. Protects grain for up to 12 months at an application rate of 8.6 oz, and up to 18 months at the 11.5-oz rate.<br><br>Apply 3 fl oz of Actellic in 2 gallons of water per 1,000 sq ft of surface area as a cap-off treatment *if the entire grain mass is not treated*. Apply half of the mixture to the grain surface and rake into the top 4 inches; then apply the other half to the raked surface. | Do not apply to barley, oats, soybeans, or wheat. Do not apply before high-temperature drying.<br><br>Controls weevils, secondary beetles, and Indianmeal moth. Dry grain to 14 to 15% moisture for pirimiphos-methyl to persist for 1 year or longer. Cap-off treatments do not provide control of insects active beneath the treated layer. |
| Pyrethrins plus piperonyl butoxide | Barley, corn, oats, rye, sorghum, sunflower, wheat | Rate depends upon the product concentration. Follow label directions of the product in use. | Do not apply to soybeans. Short-term residual activity. Useful mainly as a surface spray or aerosol to control larval and adult Indianmeal moths, as well as other pests at the grain surface. |

Diatomaceous earth is an abrasive and slightly sorptive dust that damages an insect's body covering and causes death by dehydration. Incorporating surface treatments should provide some control of insects active in the treated layer.

Problems associated with the use of diatomaceous earth as a grain protectant throughout a grain mass include increased wear to grain-moving equipment, the generation of great amounts of airborne dust during grain handling, and possible reductions in test weight. In addition, diatomaceous earth is not very effective when the grain is wet.

Grain that is identified as having been treated with diatomaceous earth is not downgraded when inspected by official grain graders, but some buyers refuse to accept grain treated with diatomaceous earth if the appearance of the grain is altered by a dusty coating. Conversely, buyers of organic foods or feeds accept grains treated with diatomaceous earth or *Bacillus thuringiensis*, but not grains treated with synthetic chemical insecticides. Due to its cost and the drawbacks discussed, using diatomaceous earth to treat an entire grain mass by admixture at the auger, conveyor belt, or bucket elevator is not advised except in unique circumstances, such as the long-term storage of organically certified grains. For topdress applications, diatomaceous earth gives satisfactory results. Another successful and practical use of diatomaceous earth has been its addition to small seed packets to prevent infestation by stored-product pests.

## Sampling Stored Grain

Stored grain should be monitored regularly to determine grain moisture content and temperature and to detect insect infestations. Sample stored grain for insects at least monthly from November through April and at least twice monthly from May through October. Pay particular attention to the grain surface and the central core of the grain mass, but also sample additional locations and depths. Examine grain from any locations where temperature or moisture readings are substantially higher than average. Deep-bin probes and sectioned grain triers are most commonly used for withdrawing samples from beneath the grain surface. Probe traps and sticky pheromone traps also are available for monitoring insects within the grain mass and flying moths, respectively. Sampling equipment is available from most bin sales and service companies.

## Controlling Established Infestations

When insects are found in stored grain, a logical question is: Are there enough insects present to warrant control? The importance of an insect infestation is determined not only by insect numbers but also by type of grain, insect species, time of year, grain temperature and moisture, the planned duration of storage, market potential, and local elevator quality and dockage guidelines. Revised (1988) Federal Grain Inspection Service (FGIS) standards for grain insect infestation are presented in Table 2, but local elevators may enforce more stringent standards. Insect-damaged kernels also may result in price discounts.

**Table 2. Number of live insects (per kilogram of grain) required for FGIS designation as "infested"**

| Crop | Insect number (per kilogram) for designation as "infested" |
|---|---|
| Wheat, rye, triticale | 2 or more live insects that are injurious to stored grain |
| Barley, corn, oats, sorghum, soybeans | More than 1 live weevil *or* |
| | 1 live weevil plus 5 or more other live injurious pest insects *or* |
| | No live weevils, but 10 or more other live pest insects injurious to stored grain |

### Options

When insects are detected in stored grain, consider several possible management practices. Sometimes the most profitable action is to clean and sell the grain immediately without any chemical treatment. Immediate sale is appropriate if early stages of insect infestations are detected before insect numbers reach a buyer's detection or discount level. During cool weather, aerating to cool the grain below 50°F prevents insect activity and allows an extended period of safe storage.

Sometimes insect problems are limited primarily to the surface or central core of stored grain. If Indianmeal moth is the only problem, light infestations can be controlled by using *Bt*, Actellic, Reldan, Storcide II, or diatomaceous earth as outlined in Table 1. Unincorporated applications of these insecticides will not control Indianmeal moth larvae already present a few inches below the grain surface. Where abundant webbing indicates a severe infestation, webbing should be raked from the surface before treating; fumigation may be necessary in these situations. If secondary beetles are confined primarily to a central core of fine material, removing one or two loads of grain to extract that core may allow safe storage of the remaining grain.

Infested grain that cannot be treated successfully in any other way should be fumigated. Safety concerns and protective equipment requirements for fumigants suggest that fumigating farm-stored grain is potentially dangerous and difficult. Hiring a professional fumigator is strongly recommended, especially for the fumigation of bins with capacities greater than 5,000 bushels.

### Fumigation Steps

*Persons not trained and certified specifically in the use of grain fumigants should not attempt to fumigate stored grain. The steps outlined provide general guidelines but not complete directions.*

1. Choose a calm, warm day when the grain temperature is above 60°F. Farmers and elevator operators should use only aluminum phosphide fumigants for grain fumigation. Dry fumigants containing aluminum phosphide include Fastphos, Fumitoxin, Gastoxin, Phostek, Phostoxin, and Weevil-cide. Aluminum phosphide is a restricted use fumigant.
2. Learn and follow all safety regulations and precautions. Always use at least two trained people to fumigate; never fumigate alone. An observer also should be present *outside* the bin.
3. Plan your bin fumigation so that you are in the bin for the least amount of time possible, 15 to 20 minutes at the most.
4. Level the surface of the grain, break up any caked or crusted areas, and remove webbing.
5. Use tape and plastic sheeting to thoroughly seal all cracks and holes in the bin; seal the side door and unloading auger shaft. If the grain surface will not be tarped, also seal the eaves and roof hatches. Leave only the necessary access openings to seal after fumigant application.
6. If the grain surface is to be tarped (we encourage this), precut a piece of polyethylene sheeting to fit over the surface of the grain. The sheeting should be cut to allow for tucking about 2 feet around the edge between the grain and the bin wall.
7. Plan for one person to work with the polyethylene sheeting and take gas readings and the other person to probe the aluminum phosphide tablets or

pellets. The proper respiratory protection equipment and gas-reading devices should be on hand.

8. The minimum requirement for respiratory equipment is two full-faced, canister-type gas masks with a canister approved for the fumigant being used (phosphine gas for aluminum phosphide). The canister gas mask must be worn when the concentration of phosphine gas is between 0.3 and 15 ppm. Two self-contained breathing systems should also be readily available in case the concentration of phosphine gas exceeds 15 ppm.

9. Fumigators must measure fumigant gas concentrations during fumigation to determine the appropriate respiratory protection. Follow specific label directions concerning respiratory-protection equipment and gas-detection devices. A device that allows passive monitoring of worker exposure, the Draeger badge, also can be used to measure exposure to phosphine. Consult fumigant suppliers for more information about this device.

   *Failure to follow all label instructions is unsafe and illegal.* If you are uncertain about the safe use of a fumigant, contact the manufacturer for detailed recommendations.

10. Use a probe to place aluminum phosphide tablets or pellets in the grain mass. In farm bins, use 90 to 180 tablets or 450 to 900 pellets per 1,000 bushels of bin capacity. However, because phosphine is a mobile gas and penetrates to all parts of the storage structure, determination of dosage per cubic feet of storage space may be more accurate, especially if the surface of the grain to be fumigated is not tarped. In farm bins, use 70 to 145 tablets or 350 to 725 pellets per 1,000 cubic feet of space. Rates vary among different types of storage structures.

    Do not allow water to come into contact with tablets or pellets; wear cotton gloves to prevent perspiration from reaching the dry material.

11. Probe the aluminum phosphide tablets or pellets on 5-foot centers by starting at the point farthest from the hatch and working toward the hatch. Place about 10 to 20 tablets or 50 to 100 pellets per probe. The probe should be pushed into the grain as quickly as possible.

12. After application, finish tarping the grain surface. Secure a length of cord or rope to the polyethylene sheeting and extend the cord or rope out of the bin hatch. This allows you to remove the polyethylene sheeting after the fumigation is complete without climbing into the bin. Lock the bin securely.

13. Place some aluminum phosphide fumigant into the aeration fans and cover the ends of the fans with polyethylene sheeting. Make certain the aeration ducts are dry before you add the fumigant tablets or pellets.

14. Place warning placards on all doors and near ladders as directed by the fumigant label. Placards must bear the words **DANGER/PELIGRO** and the skull-and-crossbones symbol. Placards must identify the date of fumigation; the name of the fumigant applied; and the name, address, and telephone number of the applicator. Each placard must state: **AREA UNDER FUMIGATION. DO NOT ENTER/NO ENTRE.**

15. Spray the outside surface of the bin with chlorpyrifos-methyl or cyfluthrin.

16. Wait at least 72 hours after aluminum phosphide application before airing out bins; follow label directions. After aeration, fumigant concentrations must be measured before warning placards may be removed and before the grain may be fed or processed.

17. After it is aired out, fumigated grain is subject to reinfestation. Surface application of a protectant insecticide should follow fumigation if storage is to continue.

*Labels of products containing aluminum phosphide currently are undergoing changes. Rates of application and how and where aluminum phosphide can be used will be changed. Always follow label directions.*

### Atmospheric Gases and Other Fumigants

The atmospheric gases carbon dioxide and nitrogen (alone or in combination) can be used successfully as grain fumigants. These gases are supplied for fumigation by stationary or portable generators or are delivered in pressurized tanks. The fumigant gas must be introduced into storage in a manner that displaces the original air volume; then an adequate concentration (usually 40 to 60 percent by volume) must be maintained for a period of 4 to 10 days (longer in cool grain). For these reasons, thorough sealing is especially important. Sealing the "seams" in bolted farm bins is necessary to reduce carbon dioxide leaks. Fumigation with atmospheric gases leaves no toxic residues after the treated commodity is aerated, but it is important to remember that carbon dioxide concentrations reach toxic levels in work areas during application. Applicators and other workers must wear respiratory protection (a self-contained breathing apparatus) during periods of exposure.

Fumigation with atmospheric gases currently is conducted by only a few professional fumigators and by a few large grain companies that maintain equipment at their storage sites. Where available, fumigation with carbon dioxide, nitrogen, or both can be cost competitive and effective.

Fumigants containing carbon dioxide plus phosphine gas ($ECO_2$fume) and sulfuryl fluoride (Pro-Fume) are now registered for use in grain fumigation. These fumigants are effective for stored-grain insect control, but their effective use requires special training and equipment. They should be used only by professional fumigators.

### Beneficial Insects

One or more companies market programs that call for periodic releases of beneficial insects (predators and parasitoids of pest species) for pest management in stored grains. Although considerable research has been directed at this practice, questions remain unanswered concerning the ability of releases of beneficial insects to lower pest populations to levels required by current grading standards. Published studies conducted in on-farm storage sites have not achieved adequate levels of control.

Where management efforts must be limited to "nonchemical" methods of control, sound cultural practices (sanitation, adequate drying, cleaning, aeration, and annual rotation of the commodity) outperform the release of beneficial insects.

## Special Considerations for Stored Seeds

Seed corn in bulk storage (in cribs, bins, and granaries) can be protected from insect damage by using the storage practices and protectant insecticides discussed previously. These practices include proper sanitation, drying, cleaning, and temperature management (aeration), and the use of protectant insecticides like pirimiphos-methyl (Actellic or Nu-Gro Insecticide S.P.), *Bt*, and pyrethrins plus piperonyl butoxide. Where fumigation of bulk-stored seed corn is necessary, aluminum phosphide fumigants or carbon dioxide can be used effectively without affecting seed germination.

In bagged seed corn (usually not treated with any insecticide), several stored-grain insects may be a problem, but the Indianmeal moth is the most common. Although bulk seed treatments with Actellic, *Bt*, or Nu-Gro provide residual control of Indianmeal moth larvae, such treatments must be applied before or during bagging. Small quantities of valuable seed can be protected by cool storage or by adding diatomaceous earth to seed packets. To limit infestations of insects in untreated, bagged seed corn, warehouses may be fogged periodically during the summer with pyrethrins plus piperonyl butoxide. Using proper warehouse sanitation methods, maintaining cool temperatures, and excluding pests (by using screens, tight-fitting doors and windows, caulking, and so forth) also are important. Bagged seed can be fumigated effectively with aluminum phosphide fumigants. Hiring a professional fumigator is advised.

## For Further Information

Additional information about pest management in stored grains may be obtained from the following sources:

*Picture Sheet X798.01, Stored Grain Insects and Molds.* Available from ACES/ITCS Marketing and Distribution, 1917 S. Wright St., Champaign, IL 61820; (800)345-6087.

*Illinois Pesticide Applicator Training Manual 39-4: Seed Treatment.* Available from ACES/ITCS.

*Illinois Pesticide Applicator Training Manual 39-8: Grain Facility.* Available from ACES/ITCS.

*Stored Grain Pest Management* (SP39-8-CD), self-study CD-ROM. Available from ACES/ITCS.

*Stored Product Management.* Publ. E-912. Available from the Department of Entomology, Oklahoma State University, 127 Noble Research Center, Stillwater, OK 74078.

For a list of addresses of suppliers of insect traps, other sampling equipment, and insecticide application equipment (for stored grains), write to the Department of Crop Sciences, S-322 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801.

## Recommended Web Resources

**http://pasture.ecn.purdue.edu/~grainlab/**
Postharvest grain quality and stored-product protection. Excellent lists of educational resources, including links to online publications.

**http://www.usgmrl.ksu.edu/**
Current research in USDA–ARS.

**http://www.insectslimited.com/**
Commercial fumigation services and supplies, fumigation alternatives, current important issues regarding fumigation and other stored-grain management strategies.

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# 6

# Insect Pest Management for Livestock and Livestock Buildings

## Contents



## Tables



## Updates for 2006

Changes in this chapter for 2006 reflect the registrations during the last 2 years of Elector, a product that contains spinosad, and of an ivermectin bolus. Elector is labeled for application to beef and dairy cattle and as a premise spray for fly control. The ivermectin bolus is labeled for administration to beef cattle for control of grubs, lice, and horn flies. Products containing methoxychlor have not been manufactured for a few years now, so listings of methoxychlor have been deleted from this chapter this year. Those who still possess methoxychlor products may use them according to the label.

Over the past few years, several products containing one of the avermectins (the group of compounds that includes ivermectin/Ivomec) have been labeled for controlling grubs, lice, ticks, and mites on beef cattle, nonlactating dairy cattle, and/or swine. See the product listings in the following tables for specific products. Also be aware that many "private label" formulations of the same active ingredient are sold under different trade names. It is not possible for this publication to list all of those trade names. Be sure to check product labels for the common name of the active ingredient, and follow all label directions, especially those covering dilution, application rate, protective equipment, and preslaughter intervals.

Farnham and other suppliers now market a fly trap known as the Epps trap. It works on the idea that a dark silhouette attracts biting flies. Flies that buzz around the trap collide with clear panes or "deflectors" and drop into a trough of soapy water that traps and kills them. These traps *do* catch large numbers of certain biting flies (horse flies, deer flies, and stable flies), and trials have shown that they can reduce the number of flies attacking animals in the area around a trap. These traps *do not* attract or control face flies, house flies, or horn flies. Promotional literature suggests using one trap per 40 acres, but the number of traps needed for a specific area is not well established. Use fencing around these traps (and anything else placed in a pasture) to prevent cattle from damaging them. Expect retailers to charge from $150 to $200 for these traps.

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

Successful pest management is an essential part of efficient and profitable livestock production. Although pest-related losses are often inconspicuous, flies, lice, mites, and ticks can cause significant reductions in meat, milk, wool, and egg production. Several livestock pests also transmit important diseases.

Effective management of livestock pests should include the use of cultural, mechanical, and biological control tactics as well as the application of chemical insecticides. Insecticides should be viewed as supplements to, not replacements for, sanitation and sound cultural practices. Used properly, insecticides efficiently reduce pest populations with no injury to livestock or threat to safety of the pesticide applicator or the ultimate consumer of animal products.

This chapter provides recommendations for safe and effective use of livestock insecticides. Always use the current year's handbook. Registration changes that occur between revisions are announced to appropriate media sources and Extension offices. If you have questions about insecticides for livestock insect management, or if listed insecticides fail to provide pest control, please contact your local University of Illinois Extension office.

## Using Livestock Insecticides

The pesticide user is always responsible for the results of insecticide applications to the user's livestock and crops, as well as for problems of pesticide drift and contamination. All users should observe the following rules.

- Read the label and follow directions and safety precautions. Be sure that the insecticide is specifically labeled for the pest and animal in question and the application method planned. *THE LABEL IS THE LAW.*
- Use face masks or respirators and protective clothing during spraying. Avoid breathing spray mist or dust.
- If pesticides are spilled on the skin or clothing, wash thoroughly with soap and water and change clothes.
- Do not eat, drink, or smoke when handling pesticides.
- Provide adequate ventilation when applying pesticides.
- Do not exceed registered rates of application. Improper or excessive applications can endanger livestock and result in illegal residues in meat and milk.
- Obey the preslaughter interval on the label.
- Avoid drift to adjacent cropland, yards, woodlots, lakes, and ponds. Some materials may injure or kill fish, wildlife, and crops.
- Do not treat animals that are sick, overheated, or stressed from shipping, dehorning, castration, recent weaning, or other causes.
- Avoid contamination of feed, mangers, water, milk, and milking equipment.
- Do not spread treated manure on crops that are not listed on the pesticide label.
- Accurately record all pesticide use. Include the pesticide's trade name, formulation, dilution, application rate, and date of treatment.
- Store pesticides in their original, labeled containers, safely locked away from children, pets, and livestock.
- Dispose of empty pesticide containers promptly and properly according to specified recommendations. Do not breathe smoke from burning containers.
- Contact a physician at once in all cases of suspected poisoning. Symptoms of organophosphate poisoning include blurred vision, abdominal cramps, and tightness in the chest.

## Preventing Livestock Poisoning

Livestock animals may be killed by consuming pesticide granules, wettable powders, and dusts that have been spilled on trucks, wagons, and soil surfaces. Animals consume the pesticide alone or with feed grains or forage placed on the contaminated surface. Prevent livestock poisoning by properly containing and disposing of spilled pesticides and by storing all pesticides in locked facilities that are inaccessible to domestic and wild animals, as well as to children.

## Fly Control in Livestock Buildings and Feedlots

Filth fly species that commonly inhabit livestock dwellings, feedlots, and nearby buildings include the house fly, stable fly, little house fly, and several blow fly species. These flies develop in a variety of moist, organic wastes including manure, spilled feed, decaying vegetation, and garbage. Common breeding sites are around feed bunks, at the edges of feeding floors, under fences, along stacks of hay or straw, in accumulations of manure, and in waste-drainage areas.

Although stable flies are biting flies that take blood meals from cattle, horses, and hogs, most other flies associated with confined livestock are nuisance pests, not blood feeders. Neither stable flies nor nonbiting nuisance flies spend much time on their animal hosts, so successful fly control around confined livestock does not center on animal treatments. The use of dust bags, oilers, or ear tags provides little or no control of flies in or around buildings. Sprays directed to the legs and bellies of cattle, horses, and hogs (apply as recommended in Tables 2 through 8 for horn fly control on individual livestock species) may provide short-term relief from stable fly attack, but such applications are not likely to reduce significantly the overall fly problem.

Thorough sanitation is especially important for the control of flies around livestock buildings and feedlots. Scraping lots, removing bedding from stalls, and removing manure from under fences and feed bunks at 7- to 10-day intervals prevent fly development. Where feasible, spreading manure where it can dry rapidly averts problems with continued development of flies in manure piles. Another effective way to handle animal wastes is to pile manure near the feedlot and keep it covered with a black plastic tarp. Applying an insecticide to the borders of the pile and covering the edges of the tarp with dirt prevent flies from entering or leaving the pile. Fly development can also be retarded by using sawdust instead of other materials for animal bedding.

Sanitation also includes removal of other development sites. Because grain, hay, and silage spilled outside bunks or feeders provide breeding sites for stable flies, frequent removal of wasted feed is recommended. Where large, round hay bales are kept outside, thousands of stable fly larvae may develop in the wet, rotting portion of each bale that touches the ground. Storing hay in sheds or under tarps reduces stable fly breeding. Keeping water tanks and hydrants leak free and grading or filling lots to improve drainage also discourage fly breeding.

Insecticide applications may be necessary in addition to good sanitation. Unless otherwise indicated, premise treatments listed in Table 1 may be used in beef, dairy (other than milking rooms), swine, sheep, goat, poultry, and horse facilities. Separate recommendations are provided for fly control in milking rooms.

## Recommended Web Resources

**http://www.isis.vt.edu/~fanjun/text/Link_pest31.html**
The livestock insects portion of the Virginia Tech site contains links to many other livestock entomology references.

**http://www.oznet.ksu.edu/dp_entm/extension/InsectID/Mock/liveent.htm**
This site provides access to a series of fact sheets on the fundamentals of livestock entomology by Don Mock of Kansas State University.

**http://www.uky.edu/Agriculture/Entomology/entfacts/eflivstk.htm**
This is the livestock insects portion of the University of Kentucky's entomology site. It links to fact sheets on livestock insects and their management.

**http://ipmwww.ncsu.edu/vetent/expert.html**
Richard Axtell of North Carolina State University developed this site, which contains links to downloadable expert systems computer programs titled *Livestock Pest Expert System, Fly Management Simulator,* and *Poultry Pest Expert System.*

**http://www.uky.edu/Agriculture/Entomology/entfacts/livestc/lvstkcal.htm**
This site contains the University of Kentucky's livestock insects calendar.

**Table 1. Fly control in livestock buildings and feedlots**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC.** | Space spray from mist blower or fogger | To minimize control failures caused by insecticide resistance, do not apply a single insecticide repeatedly throughout an entire season. Alternate applications of pyrethroids (permethrin products) and organophosphates (naled and dichlorvos). Space sprays (aerosols) provide rapid control of adult flies present at the time of application. Close doors and windows to reduce air movement during treatment. Daily to twice-weekly applications may be necessary where space sprays are the only treatments used. Animals may be present during application, but space sprays should not be applied directly to livestock. Do not apply space sprays in areas where animals have been treated directly with an insecticide during the previous 24 hours. Do not contaminate feed or water or use in milking rooms. | | |
| | | Vapona 40.2%EC (dichlorvos) | 2 qt to 1 gal./50 gal. water. Use 1 pt to 1 qt/8,000 cu ft or 1,000 sq ft. | 0 days. See label for instructions on diesel oil fogging. |
| | | Vapona Feedlot 43.2%EC (dichlorvos) | 1 gal./100 gal. water. Use 5 gal./acre. | 0 days. For cattle feedlots only. |
| | | Dibrom 8E (58%EC) or 1% Ready-to-Use Spray (naled) | 1 pt 8E/20 gal. water. Use 5 gal. dilute spray per acre of lot. Apply in mist blower or fogger. | 0 days. |
| | | Ectiban, Hard Hitter, or Insectaban 5.7%EC (permethrin) | *Misting:* Use 4 fl oz/1,000 cu ft.<br><br>*Overhead system:* 1 qt/12.5 gal. fuel or mineral oil; use 4 fl oz/1,000 cu ft. | 0 days. |
| | | Permectrin II 10% or Atroban 11%EC (permethrin) | *Misting:* Use 4 fl oz/1,000 cu ft.<br><br>*Overhead system:* 1 qt/25 gal. fuel or mineral oil; use 4 fl oz/1,000 cu ft. | 0 days. |
| | | Additional insecticides that contain permethrin may be labeled for use as aerosol sprays. Read and follow label directions. | | |
| | | pyrethrins plus synergist | Follow label directions. | 0 days. |

**Table 1. Fly control in livestock buildings and feedlots (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC. (CONT.)** | Surface-residual spray | To minimize control failures caused by insecticide resistance, do not apply a single insecticide repeatedly throughout an entire season. Alternate applications of pyrethroids (cyfluthrin, fenvalerate, lambda-cyhalothrin, and permethrin), spinosad, and organophosphates (diazinon, stirofos/dichlorvos). Surface sprays applied to walls, ceilings, partitions, posts, etc., kill flies at their resting sites and provide residual activity for 1 to 7 weeks. Products (or the listed concentrations of these products) recommended for use as residual sprays should not be applied directly to animals. Thoroughly spray surfaces to the point of runoff. Do not contaminate feed or water, and do not use residual sprays in milking rooms. See product labels for directions on use with sugars or molasses in bait sprays. | | |
| | | Countdown 20WP or 2EC; Tempo 20WP or 2SC (cyfluthrin) | See product labels. | 0 days. Remove animals before spraying. |
| | | Dryzon 50%WP and other trade names (diazinon) | 2 lb/25 gal. water. Use 1 gal./350 to 750 sq ft. | Not for use in dairy or poultry buildings. Remove animals before spraying. Keep them out for at least 4 hours. Some residual activity persists 2 to 4 weeks. |
| | | Elector 2.46% (spinosad) | 20 fl oz/10 gal. water | 0 days. Do not apply to poultry, swine, or sheep facilities when animals are present. Allow surfaces to dry completely before animals reenter. |
| | | Ectrin 10%WDL (fenvalerate) | 1 qt/10 gal. water. Use 1 gal./750 sq ft. | 0 days for swine buildings. Use only in swine buildings and in horse barns where horses are not to be slaughtered. Some residual activity persists 3 to 7 weeks. |
| | | Grenade 10%WP or 9.7%ER (lambda-cyhalothrin) | Dilute as directed. | 0 days. See label. |
| | | Ectiban 25%WP or 5.7%EC (permethrin) (Atroban, Expar, Hard Hitter, Insectaban, Insectrin, Overtime, Permaban, and Permectrin II are other permethrin products registered for use as surface-residual sprays.) | 6 oz 25%WP/ 11 gal. water or 1 qt 5.7%EC/ 12.5 gal. water. Use 1 gal./750 sq ft. | 0 days. Some residual activity persists 3 to 7 weeks. |

**Table 1. Fly control in livestock buildings and feedlots (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC. (CONT.)** | Surface-residual spray (cont.) | GardStar 40%EC (permethrin) | 4 fl oz/10 gal. water. | 0 days. Some residual activity persists 3 to 7 weeks. |
| | | (Pounce is another permethrin product that may be used as a residual spray. It is classified for restricted use; do not apply Pounce directly to poultry or livestock.) | | |
| | | Ravap 28.7%EC (stirofos plus dichlorvos) | 1 qt/6 gal. water. Use 1 gal./500 to 1,000 sq ft. | 0 days. Some residual activity persists 2 to 4 weeks. |
| | Bait | Baits may enhance house fly control; they do not attract stable flies. Bait applications of insecticides used in surface-residual sprays may be prepared by adding sugar or corn syrup to the spray-tank mixture. Follow directions on individual product labels. Dry baits may be sprinkled in areas where flies congregate. Do not place dry baits in areas where birds or animals may contact the bait. Do not contaminate feed or water. | | |
| | | Apache, Fly Bait Plus, Golden Malrin, Musca-cide, or Tailspin 1% Dry Bait (methomyl) | 4 oz/1,000 sq ft. | 0 days. |
| | | Dipterex 1% Dry Bait (trichlorfon) | 4 oz/1,000 sq ft. | 0 days. |
| | | QuickBayt 0.5% Dry Bait (imidacloprid) | Follow label directions. | 0 days. |
| | | Quick-Strike 1% (nithiazine) | Ready-to-use strip. Hang 1 strip/100 to 300 sq ft. | 0 days. |
| | Manure spray | Manure sprays control fly larvae that are developing in treated feces. Migration of adult flies from nearby areas may occur if any breeding sites remain untreated. Manure sprays are recommended only where manure cannot be removed on a weekly basis. Apply sprays at rates that wet the manure surface; soaking is not necessary. Repeat applications as necessary but not more often than every 7 days. Do not apply where mammals or birds may come in contact with the manure. Do not apply treated manure to crops not listed on the insecticide label. | | |
| | | Larvadex 5%SC (cyromazine) | 1 qt/25 gal. water. Use 1 gal./100 sq ft manure, pit, or lagoon surface. | 0 days. |

**Table 1. Fly control in livestock buildings and feedlots (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC. (CONT.)** | Manure spray (cont. ) | Vapona 40.2%EC (dichlorvos) | 1 gal./100 gal. water. Use 1 to 2 qt/ 100 sq ft manure. | 0 days. |
| | | Ravap 28.7%EC (stirofos plus dichlorvos) | 1 gal./25 gal. water. Use 1 gal./100 sq ft manure. | 0 days. |
| | Feed additive | Feed additives used to prevent the development of fly larvae in feces provide minimal control of flies in livestock buildings. Feed additives do not reach house fly and stable fly larvae that develop in sites other than fresh manure. Good sanitation more effectively prohibits larval development. Animals must consistently consume recommended dosages for feed additives to be effective against fly larvae in manure. | | |
| | | Larvadex 0.3% Premix (cyromazine) | 1 lb/ton of feed. Mix thoroughly. | Poultry only. Feed to laying hens only; not for broilers or poultry producing eggs for hatching purposes. Continuous use of cyromazine has led to fly resistance. |
| | | Moorman's 0.02% IGR (methoprene) | 0.25 to 0.5 lb/100 lb body weight/ animal/month. | 0 days. Feed mineral mix or block from May through September. Beef cattle and dairy cattle only. |
| | | Rabon 7.76% or 97.3% Oral Larvacide (stirofos) | 70 mg a.i./100 lb body weight/day. See label for dilution tables. | 0 days. Use from May through September. Mix with complete feeds, concentrates, or protein supplements. For beef cattle, dairy cattle, hogs, and horses only. |
| | Biological agent | **Alternative Methods of Fly Control**<br>Several companies sell parasitic wasps for use in controlling flies around livestock buildings and feedlots. These tiny parasitic wasps attack only flies; they do not sting (or bite) other insects, animals, or humans. Adult wasps (less than 1/10 inch long) deposit eggs on or inside fly pupae. Developing wasps kill the immature flies. Suppliers usually recommend wasp releases (several thousand wasps per release) before and during the fly season.<br><br>Most biological control programs recommend periodic removal of manure, effective water management, and control of weeds around feedlots and buildings. Some suppliers also recommend certain insecticide applications to supplement the control provided by biological agents. In many instances, it is difficult to assess the separate impacts of parasitic wasps, sanitation practices, and insecticide applications. Although wasp releases have been shown to be effective for fly control in certain poultry housing, research data indicate that other uses of currently available biological controls for flies often are not effective. If biological control agents are to contribute significantly to fly control programs, integration with sanitation and chemical control practices is essen- | | |

**Table 1. Fly control in livestock buildings and feedlots (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC. (CONT.)** | Biological agent (cont.) | | | **Alternative Methods of Fly Control (cont.)** tial. Although any use of parasitic wasps must be considered experimental, existing data indicate that, in the Midwest, *Spalangia nigroaenea* is the species most likely to parasitize house fly and stable fly pupae in feedlots. *Muscidifurax raptor* and *Muscidifurax zaraptor* contribute to house fly parasitism; *Spalangia nigra, Spalangia cameroni,* and *Spalangia endius* contribute to stable fly parasitism. Not all of these species are consistently available for purchase, but producers should ask suppliers what species will be provided. Producers should not buy a blend of unspecified parasites or shipments that contain *Nasonia vitripennis,* a species shown to be ineffective in Midwest feedlots. |
| | Trap | | | Traps (including bait stations) that release an odor to attract flies are designed to attract and kill house flies, not stable flies. Such traps are sold under a variety of trade names for use around livestock facilities. These traps capture great numbers of house flies but often do not substantially reduce the dense house fly populations that develop at livestock facilities. We do not recommend reliance on such traps; but, if they are used in attempts to control house flies, producers should use several traps at each facility.<br><br>Electrocuting light traps attract and kill some house flies and stable flies, but these traps are only rarely useful around livestock operations. Where electrocuting light traps can be placed indoors in locations that do not attract insects from outdoors, they may reduce adult house fly and stable fly populations slightly. Electrocuting light traps are most likely to provide the greatest benefit in closed buildings such as horse barns.<br><br>Traps made of alsynite, a fiberglass-like product, are attractive to stable flies and may reduce overall populations if enough traps are used. How many traps are needed in different circumstances is not known. Alsynite traps are available from Olson Products, P.O. Box 1043, Medina, OH 44258.<br><br>White pyramid-shaped traps that are attractive to house flies and stable flies are also available commercially. These use an electrocuting grid and sticky surfaces to kill or trap flies. Prototypes tested in other states have been useful in reducing fly numbers. These traps are also sold by Olson Products at the above address. |
| | Diatomaceous earth | | | The insecticidal activity of a range of chemically inert dusts, including diatomaceous earth, results from their abrasiveness or their sorptive characteristics or both. To understand how these dusts kill insects, it is important to recognize that an insect's body covering, the cuticle, contains fat layers that make the cuticle nearly waterproof and prevent water loss. Sorptive dusts absorb fats, disrupting the cuticle's waterproof nature. Abrasive dusts damage the insect's water barrier by actually scratching or cutting the cuticle. Where inert dusts are effective as insecticides, dehydration usually causes the insect's death.<br><br>For animal ectoparasite control, dusts that are sorptive or abrasive or both have been used somewhat successfully for reducing populations of lice, fleas, and some mites on a range of animal species and humans. Although most tri- |

**Table 1. Fly control in livestock buildings and feedlots (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **HOUSE FLIES, STABLE FLIES, BLOW FLIES, ETC. (CONT.)** | Diatomaceous earth (cont.) | **Alternative Methods of Fly Control (cont.)** | | als have evaluated silica aerogels, diatomaceous earth was used effectively to control biting lice on cattle in a study conducted in the 1930s. Silica aerogels were used at a rate of 1 to 2 oz of dust per cow; diatomaceous earth was applied at a rate of 3 oz per cow. Based on available evidence, it is likely that although diatomaceous earth does not work as well as currently available chemical insecticides, it should provide some control of lice, fleas, and certain mites if applied thoroughly and repeatedly. Given the skin-burrowing habits of swine mange mites, producers should not expect diatomaceous earth to control this pest. Like all other pesticides, insecticides containing diatomaceous earth may be used only according to USEPA-approved label directions.<br><br>Advertisements claim that diatomaceous earth used as a feed additive provides control of internal parasites and also control of fly larvae in animal manure. Sales materials also include claims of controlling adult flies by aerosol, dust bag, or hand-dusting applications of diatomaceous earth to barns and animals. No reliable data support these claims of fly control. |
| **FLIES IN MILKING ROOMS** | | | | Although effective fly control is essential in dairy barns and milkrooms, small amounts of pesticides can be detected in milk, and their presence is often illegal. To control flies and avoid residue problems, the following steps are recommended:<br>1. Use good sanitation and recommended insecticides in dairy barns to reduce the number of flies entering the milkroom.<br>2. Use sticky fly strips where appropriate.<br>3. Use tight screens (14 to 16 mesh) on milkroom doors and windows. Copper, aluminum, bronze, plastic, or rust-resisting screens are best.<br>4. Use a mist or aerosol spray of 0.06 to 0.1% pyrethrin plus piperonyl butoxide oil-based fly sprays in the milkroom when other methods do not give adequate fly control. To prevent milk contamination, cover all milking utensils, cans, bulk tanks, and containers before spraying. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE** 1/16 to 1/8 inch long. Biting lice are reddish, flattened, and active. Sucking lice are gray to blue and sluggish. Heavy populations cause poor growth, general unthriftiness, and anemia. Symptoms are rough, patchy hair coats and a dirty appearance. Lice are most troublesome during winter months. | **Most insecticides registered for use against grubs provide short-term control of lice.** However, infestations of biting lice have been observed on Illinois cattle despite their injection with ivermectin (Ivomec) according to label directions.<br><br>Self-treatment devices such as back rubbers, face rubbers, and dust bags effectively control lice when used in conjunction with systemic insecticides applied from August through October for grub control. The systemics kill lice that are present on animals during the fall; the self-treating devices then hold louse populations below economic levels throughout the winter. Place rubbing devices and dust bags where cattle will use them. For back rubbers and face rubbers, mix insecticides with no. 2 fuel oil, no. 2 diesel fuel, or an oil recommended on the insecticide label. Mineral oil is less irritating than fuel oil. Do not use waste oil or motor oil. Keep dust bags dry. Service self-treating devices as necessary. | | | |
| | Back rubber or face rubber (oilers) | Co-Ral 11.6%EC (coumaphos) | 1 gal./13 gal. fuel or mineral oil. | 0 days. Do not apply with oral drenches, with other internal medications (such as phenothiazine), or with natural or synthetic pyrethroids, synergists, or organophosphates. |
| | | malathion 57%EC | 0.5 pt/1.5 gal. fuel or mineral oil. | 0 days. |
| | | Atroban DeLice or Expar (1% permethrin) | 1 pt/1 gal. diesel fuel or mineral oil. | 0 days. |
| | | DelPhos 11.6%EC (phosmet) | 1 gal./50 gal. fuel or mineral oil. | 0 days. |
| | Dust bag | Products listed for use in dust bags also may be applied by hand-dusting. Follow label directions. | | |
| | | Co-Ral 1%D (coumaphos) | Ready to use. | 0 days. |
| | | Ectiban or Permectrin 0.25%D (permethrin) | Ready to use. | 0 days. |
| | | Rabon 3%D (stirofos) | Ready to use. | 0 days. |
| | Spray | Apply sufficient spray to thoroughly wet each animal. Use up to 1 gallon finished spray per animal. Do not contaminate feed or water. | | |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE (CONT.)** | Spray (cont.) | Taktic 12.5%EC (amitraz) | 760 ml/50 to 100 gal. water. Use up to 2 gal. spray per fully grown animal. | 0 days. Apply spray within 6 hours after mixing. Repeat application in 10 to 14 days. |
| | | Co-Ral 11.6%EC or 25%WP (coumaphos) | 2 qt 11.6%EC or 2 lb 25%WP/100 gal. water. | 0 days. Do not apply within 14 days of freshening of dairy cattle. Do not treat calves less than 3 months old or cattle that are sick, convalescent, or stressed. Do not spray within 10 days after shipping, weaning, or disease exposure. Do not spray in nonventilated areas. Do not apply in conjunction with other organophosphates, pyrethroids, synergists, or phenothiazine. |
| | | Delnav 15%EC or 30%EC (dioxathion) | 1 qt 15%EC or 1 pt 30%EC/25 gal. water. | 0 days. Do not treat more often than every 14 days. Do not use on dairy cattle or in dairy barns. Restricted use. |
| | | Elector 2.46% (spinosad) | 20 fl oz/10 gal. water | 2 days. |
| | | malathion 57%EC | 1 gal./100 gal. water. | 0 days. Do not apply to lactating dairy cattle or within 14 days of freshening. Do not treat calves less than 1 month old. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/100 gal. water. | 0 days. Repeat treatment 14 to 21 days after first application. Do not treat more often than every 14 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Atroban DeLice, Expar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for control of lice on beef cattle. Check product labels for dilution and application rates.) | | |
| | | DelPhos 11.6%EC (phosmet) | 1 gal./100 to 150 gal. water. | 3 days. Do not use on animals simultaneously with or within a few days of treatment with other cholinesterase-inhibiting compounds. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE (CONT.)** | Spray (cont.) | Ravap 28.7%EC (stirofos plus dichlorvos) | 1 gal./75 gal. water. Use 0.5 to 1 gal./animal. | 0 days. Do not treat more often than once every 10 days. Do not apply to Brahman or Brahman-cross cattle. Do not apply to calves less than 6 months old. Do not use in conjunction with trichlorfon or other organophosphates. |
| | Pour-on or spot-on | Fall applications of systemic pour-ons and spot-ons such as Co-Ral (coumaphos), Ivomec (ivermectin), Neguvon (trichlorfon), Prolate (phosmet), Tiguvon (fenthion), and Warbex (famphur) or fall injections of Ivomec (ivermectin) for grub control also reduce populations of sucking lice; some of these products control biting lice. These treatments may not provide seasonlong louse control through the winter. Follow label directions concerning reuse after grub treatment cutoff dates. Products listed below effectively control lice but do not provide grub control. For best results, apply twice at 14-day intervals. | | |
| | | Dursban 44 (chlorpyrifos) | Ready to use. 2 cc/100 lb body weight. | 14 days. Beef cattle only. Apply as spot treatment. Do not exceed 16 cc/animal. Do not treat calves less than 3 months old or bulls more than 8 months old. Do not treat purebred continental or exotic breed cattle such as Charolais, Chianina, Simmental, and Gelbveih. Do not re-treat within 30 days. Do not use on cows within 21 days prior to calving or 14 days after calving. |
| | | Cylence 1% (cyfluthrin) | Ready to use. | 0 days. |
| | | Elector 2.46% (spinosad) | Ready to use. Apply 4 ml/110 lb body weight. | 2 days. |
| | | Lysoff 7.6%EC (fenthion) | 1 pt/1 gal. water. Use 1 fl oz/100 lb body weight. | 21 days; 35 days if 2 applications are made. Do not apply within 28 days of freshening of dairy cattle. Pour evenly along backline. Do not treat calves less than 3 months old or cattle that are sick, convalescent, or stressed. Do not use with other cholinesterase-inhibiting insecticides or drugs. |
| | | Saber 1% (lambda-cyhalothrin) | Ready to use. 10 to 15 ml/animal. | 0 days. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE (CONT.)** | Pour-on or spot-on (cont.) | Atroban DeLice or Expar 1% (permethrin) | Ready to use. 0.5 fl oz/100 lb body weight. Do not exceed 5 fl oz/animal. | 0 days. |
| | | Brute or Permectrin CD 10% (permethrin) | Ready to use. 1.5 ml/100 lb body weight. Do not exceed 15 ml/animal. | 0 days. Permectrin CDS and Boss also may be used for louse control. See product labels. |
| | Bolus | Ivomec SR (1.72 g ivermectin/bolus) | See label. | 180 days. Only for calves weighing 275 to 660 lb. Beef cattle only. |
| **CATTLE GRUBS** Larvae ("grubs") bore through the skin and migrate within the host to the skin of the back. Light infestations cause little or no reduction in the rate of gain or in feed efficiency. Hide damage may be economically important if cattle are slaughtered during the spring or early summer following grub emergence. The hairy, yellow and black adult flies, slightly smaller than honey bees, annoy grazing cattle. | Timing of grub-control treatments is important. Systemic insecticides applied as pour-ons, spot-ons, or sprays travel within the animal's bloodstream and should be applied to control grubs 6 to 8 weeks before they migrate to the animal's back. Late treatments may cause host–parasite reactions with symptoms of bloat, hindquarter paralysis, or death. Systemic insecticides should be used on native beef cattle herds in August or September in southern Illinois and in September or October in the northern half of the state. For native cattle, treat only summer-pastured animals in areas with histories of grub problems. Cattle more than 3 years old rarely are economically infested. Animals in confinement are not attacked by ox warble flies (heel flies). Heel fly season and grub-treatment dates are earlier for cattle grazed in southern states. Cattle feeders should know the origin of feeder cattle to determine grub-treatment dates or should purchase only cattle that have received grub treatments.<br><br>Do not apply systemic insecticides in conjunction with or immediately after phenothiazine, with pyrethrins or synthetic pyrethroids or their synergists, or with other organophosphate insecticides. Do not treat cattle under stress from castration, dehorning, weaning, shipping, illness, or overexertion. Do not treat calves less than 3 months old. | | | |
| | Pour-on | Apply pour-ons using a long-handled dipper supplied by the manufacturer. | | |
| | | Co-Ral 4% (coumaphos) | Ready to use. Apply 0.5 fl oz/100 lb body weight. | 0 days. Do not apply within 14 days of freshening of dairy cattle. |
| | | Warbex 13.2% (famphur) | Ready to use. Apply 0.5 fl oz/100 lb body weight. Do not exceed 4 fl oz/animal. | 35 days. Do not apply within 21 days of freshening of dairy cattle. Do not use on Brahman or Brahman-cross cattle. |
| | | Ivomec 0.5% (ivermectin) | Ready to use. Apply 5 ml/110 lb body weight. | 48 days. Do not treat dairy cattle of breeding age. |
| | | Cydectin (moxidectin) | See label. | 0 days. |
| | | Dectomax (doramectin) | See label. | 45 days. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **CATTLE GRUBS (CONT.)** | Pour-on (cont.) | Eprinex (eprinomectin) | 1 ml/22 lb. | 0 days. |
| | | Prolate (GX-118) 11.6% (phosmet) | 1 gal./2 gal. water. Apply 1 fl oz/100 lb body weight. Do not exceed 8 fl oz/animal. | 21 days. Do not apply to dairy animals. |
| | | Neguvon 8% (trichlorfon) | Ready to use. Apply 0.5 fl oz/100 lb body weight. Do not exceed 4 fl oz/animal. | 21 days. Do not apply within 7 days of freshening of dairy cattle. |
| | | Tiguvon 3% (fenthion) | 0.5 fl oz/100 lb body weight. | 35 to 45 days. Do not apply within 28 days of freshening of dairy cattle. |
| | Spot-on | To apply spot-ons, use the applicator system provided by the manufacturer. Apply the material to a single location on the back midline. | | |
| | | Spotton 20% (fenthion) | Ready to use. Apply 4 cc/300 lb body weight. Do not exceed 20 cc/animal. | 45 days. Do not treat dairy cattle of breeding age. |
| | Spray | Use high-pressure sprays (250 to 350 PSI) to apply 3 to 4 qt of finished spray per animal. Because few farm sprayers generate sufficient pressure for proper application, veterinarians and commercial applicators with appropriate livestock spray equipment should be contacted to apply grub sprays. Use a pencil stream of spray directed at right angles to the sides and back. Treat 10 or fewer animals in a pen or stall at one time. Do not contaminate feed or water. | | |
| | | Co-Ral 25%WP or 11.6%EC (coumaphos) | 12 to 16 lb 25%WP or 8 to 12 qt 11.6%EC/100 gal. water. | 0 days. Do not apply within 14 days of freshening of dairy cattle. |
| | | Prolate (GX-118) 11.6%EC (phosmet) | 2 gal./100 gal. water. | 21 days. Beef cattle only. |
| | Injection | Ivomec 1% (ivermectin) | Ready to use. 1 ml/110 lb body weight. | 49 days. Inject subcutaneously. Use aseptic procedures. Do not use on dairy cattle of breeding age. |
| | | Dectomax 1% (doramectin) | See label. | 35 days. |
| | Bolus | Ivomec SR (1.72 g ivermectin/bolus) | See label. | 180 days. Only for calves weighing 275 to 660 lb. Beef cattle only. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **MANGE MITES** Microscopic mites live on the skin or burrow into it. Lesions vary with mite species. Infestations are greatest when cattle are crowded in shelters during winter months. | Chorioptic mange is the most prevalent mite-induced disorder of Illinois cattle. Infested cattle may or may not develop lesions; lesions usually occur as localized nodules that exude serum. They are most numerous from the tailhead to the hind heels. Insecticides listed previously for louse control on beef cattle also control chorioptic mange mites. Cattle scabies (psoroptic mange) is a quarantinable disease. Its symptoms are lesions that occur first on the withers, over the back, and at the tailhead. Small wounds cause itching, and rubbing leads to abscesses, especially on the shoulders and rump. Mites move to edges of scabs, causing lesions to enlarge and coalesce. Scabs may cover much of the body. Accurate diagnosis requires microscopic examination of skin scrapings. Where cattle scabies is detected, contact the Illinois Department of Agriculture, Bureau of Animal Health, Illinois State Fairgrounds, Springfield, IL 62706; (217)782-4944. | | | |
| **TICKS** Eight-legged adults of most species are reddish brown and less than ¼ inch long. Engorged females may exceed ½ inch in length. Ticks are blood feeders and disease vectors. | Ticks rarely pose an economic threat to cattle in Illinois. Problems are most likely where cattle graze in brushy or wooded areas. | | | |
| | Spray | Apply sufficient spray to thoroughly wet each animal; use up to 1 gallon finished spray per animal. Do not contaminate feed or water. | | |
| | | Taktic 12.5%EC (amitraz) | 1 qt/100 gal. water. Use up to 2 gal. spray per fully grown animal. | 0 days. Apply spray within 6 hours after mixing. Repeat application in 10 to 14 days. |
| | | Co-Ral 25%WP or 11.6%EC (coumaphos) | 4 lb 25%WP or 1 gal. 11.6%EC/ 100 gal. water. | 0 days. Do not apply within 14 days of freshening of dairy cattle. Do not treat calves less than 3 months old or cattle that are sick, convalescent, or stressed. Do not spray within 10 days after shipping, weaning, or disease exposure. Do not spray in nonventilated areas. Do not apply in conjunction with phenothiazine, pyrethroids, synergists, or systemic organophosphate insecticides. |
| | | malathion 57%EC | 1 to 2 gal./100 gal. water. | 0 days. Do not apply within 14 days of freshening of dairy cattle. Do not treat calves less than 1 month old. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/100 gal. water. | Do not apply more than once every 14 days. |
| | (Additional permethrin formulations—including emulsifiable concentrates of Atroban, Expar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for control of ticks on cattle. Check product labels for dilution and application rates.) | | | |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **MOSQUITOES** Annoyance may cause cattle to bunch in or near buildings and reduce their grazing. High populations may cause reductions in rate of weight gain. | Mosquito populations are greatest near low, wet areas; ponds; and slow-moving streams. Reduction of mosquito-breeding sites is necessary for long-term control. For information on source reduction and area treatments, see *Mosquitoes in Illinois: Recommendations for Prevention and Control*, an annually revised publication available from the Illinois Department of Public Health in Springfield. The following insecticides provide some short-term relief for treated animals, but frequent applications are not economical or recommended. | | | |
| | Spray (to animals) | Vapona 40.2%EC (dichlorvos) | 1 qt/12.5 gal. water. Mist 1 to 2 fl oz/animal/day. | 1 day. Do not contaminate feed or water. Do not wet skin. Do not apply to Brahman or Brahman-cross cattle. Do not apply to calves less than 6 months old. Do not use in conjunction with trichlorfon or other organophosphates. |
| | | Ectiban 5.7% (permethrin) | 1 qt/100 gal. water. | 0 days. Do not apply more often than every 14 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for the control of mosquitoes and horse flies on cattle. Check product labels for dilution and application rates.) | | |
| | | pyrethrin (0.1%) plus synergist | Mist 1 to 2 fl oz/animal. | 0 days. Do not contaminate feed or water. Do not wet skin. |
| **HORSE FLIES, DEER FLIES** These large flies feed on the back, shoulders, neck, and head. Blood feeding annoys cattle and reduces grazing and weight gain. Wounds attract other flies. | Adequate and practical control methods are not available for horse flies and deer flies on pastured beef cattle. Insecticide applications provide some relief but do not provide long-term control. Place cattle in barns or sheds to protect them from horse flies and deer flies. | | | |
| | Spray | Ectiban 5.7% (permethrin) | 1 qt/100 gal. water. | 0 days. Do not apply more often than every 14 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for the control of mosquitoes and horse flies on cattle. Check product labels for dilution and application rates.) | | |
| | | pyrethrins (0.5 to 1.0%) plus synergist | 0.5% oil is ready to use; apply 2 fl oz/animal 3 times/week. Mix 1 gal. 1%EC/10 gal. water; apply 1 to 2 pt/animal every 3 days. | 0 days. Apply to head, back, sides, belly, and legs. Do not contaminate feed or water. |
| | Trap | See comments on page 155 regarding the Epps trap. This trap can reduce numbers of stable flies, horse flies, and deer flies. | | |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (HORN FLIES, FACE FLIES, STABLE FLIES)** | **Threshold infestations and adequate levels of control**: Horn fly infestations of up to 100 to 200 flies per animal produce little or no effect on the animal's rate of gain. In Illinois, control programs that use dust bags or oilers often reduce horn fly infestations to 10 to 50 flies per animal. The use of dust bags or oilers provides adequate and economical control of horn flies and usually does not favor rapid development of insecticide resistance (as do ear tags). | | | |
| **Horn flies** are smaller than house flies but are similarly colored and marked. They have piercing mouthparts and are blood feeders. Horn flies congregate about the back, shoulders, and horns; on hot days, they are mostly on the shady side of the animal or on the belly. Horn flies seldom follow animals into barns or sheds. | Available data do not support any estimates of what constitutes an economically damaging number of face flies or an acceptable level of face fly control. Although face flies annoy cattle, even heavy infestations do not cause reductions in their rate of gain. Face flies can transmit the pathogen that causes pinkeye, but pinkeye outbreaks also occur in the absence of face flies. | | | |
| | Research indicates that as few as 1 to 5 stable flies per leg can reduce cattle performance in some conditions. Nonetheless, there are no effective insecticide applications for reducing stable fly attacks on pastured cattle. Although sprays directed at animals' legs may provide temporary relief, no long-term control is accomplished. | | | |
| | Moving cattle into shelters reduces annoyance by horn flies and face flies, but it does not deter stable fly attack. | | | |
| **Face flies** resemble house flies but are slightly larger and darker. Only females frequently visit cattle. They feed on secretions about the eyes, nose, and mouth. | Back rubber or face rubber (oilers) | Mix insecticides with no. 2 fuel oil, no. 2 diesel fuel, or a label-recommended mineral oil. Mineral oils are less irritating than fuel oils. Do not use waste oil or motor oil. Service the rubbing device at least once per week. Self-treating devices are effective only if they are used regularly. Place rubbing devices in the entryways to water or mineral feeders to ensure usage. Effective horn fly control can be achieved with forced-use oilers; partial control of face flies is provided by these devices. Oilers do not control stable flies. | | |
| | | Co-Ral 11.6%EC (coumaphos) | 1 gal./13 gal. fuel or mineral oil. | 0 days. |
| | | Delnav 15%EC or 30%EC (dioxathion) | 2 qt 15%EC or 1 qt 30%EC/5 gal. fuel or mineral oil. | 0 days. Beef cattle only. |
| | | Ectiban, Hard Hitter, Insectaban, or Insectrin 5.7%EC (permethrin) | 1 qt/10 gal. diesel oil. | 0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags. |
| | | Permectrin II 10%EC (permethrin) | 1 qt/20 gal. fuel or mineral oil. | 0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Back rubber or face rubber (oilers) (cont.) | Ravap 28.7%EC (stirofos plus dichlorvos) | 1 qt/6 gal. fuel or mineral oil. | 0 days. |
| | Dust bag | Dust bags are effective only if they are used regularly. Place them in the entryways to water or mineral feeders to ensure use. Keep dust bags dry and well charged; service at least once per week. Forced-use dust bags that contact the animal's face provide effective horn fly control and significant reductions in face flies; dust bags do not control stable flies. | | |
| | | Co-Ral 1%D (coumaphos) | Ready to use. | 0 days. |
| | | malathion 4% plus methoxychlor 5%D | Ready to use. | 0 days. Beef cattle only. |
| | | Ectiban, Insectrin, or Permectrin 0.25%D (permethrin) | Ready to use. | 0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags. |
| | | PYthon 0.75%D (zeta-cypermethrin plus 0.1% PBO) | Ready to use. | 0 days. |
| | | Rabon 3%D (stirofos) | Ready to use. | 0 days. |
| | Feed additive | Feed additives can prevent the development of face fly and horn fly larvae in cattle dung. Stable flies do not develop in fresh dung and are not controlled by feed additives. Face flies and horn flies migrate considerable distances, so larval control in dung of a single herd may not substantially reduce fly populations if other herds in the area do not also receive boluses or feed additives. All animals must consume the recommended dosage on a regular basis for the feed additive to be effective. | | |
| | | Altosid or Moorman's IGR 0.02% (methoprene) | See labels. | 0 days. Feed mineral mix or block from May through August. |
| | | Rabon 7.76% Oral Larvacide (stirofos) | 70 mg a.i./100 lb body weight/day. | 0 days. Use from May through September. Mix with complete feeds, concentrates, or protein supplements. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Bolus | Boluses release an active ingredient that prevents the development of face fly and horn fly larvae in treated dung. Stable flies do not develop in fresh dung and are not controlled by bolus use. Face flies and horn flies migrate considerable distances, so larval control in dung of a single herd may not substantially reduce fly populations if other herds in the area do not receive boluses or feed additives. | | |
| | | Vigilante 9.7% bolus (diflubenzuron) | 0.5 to 2 boluses/animal, depending on weight. | 0 days. Use standard balling gun. Do not administer to animals weighing less than 300 lb. |
| | | Inhibitor 3% bolus (methoprene) | 0.5 to 1 bolus/animal, depending on weight. | 0 days. Use standard balling gun. |
| | | Ivomec SR (1.72 g ivermectin/bolus) | See label. | 180 days. Only for calves weighing 275 to 660 lb. Beef cattle only. Controls horn flies for up to 28 days. |
| | Ear tag or ear tape | Before widespread development of resistance in the horn fly, ear tags and tapes impregnated with pyrethroid insecticides such as fenvalerate, flucythrinate, and permethrin effectively controlled horn flies and gave some control of face flies infesting pastured cattle. One tag or tape per cow effectively controlled horn flies for up to 20 weeks. However, midseason control failures resulting from horn fly resistance have occurred throughout Illinois in recent years.<br><br>Although Max-Con tags containing cypermethrin (a newer pyrethroid) plus Dursban (an organophosphate) plus a synergist are slightly more effective against resistant horn flies than the original pyrethroid tags, they do not consistently control resistant populations and can be expected to cause an increase in the level of pyrethroid resistance. Pyrethroid tags containing the more active compounds cyfluthrin (Cutter Gold tags), lambda-cyhalothrin (Excalibur and Saber Extra tags), or zeta-cypermethrin (PYthon and ZetaGard) have initially controlled pyrethroid-resistant horn flies; but trials conducted in the southeastern United States have shown that these tags also intensify resistance and then fail to provide control.<br><br>Because resistance has already reduced the performance of pyrethroid tags and tapes, and because continued use of any pyrethroids in such devices is likely to result in even higher levels of resistance (levels that may allow horn fly survival even when pyrethroid sprays or dusts are applied), we recommend that cattle producers refrain from using pyrethroid tags or use them only once in every three or four seasons. Tags and tapes that rely on pyrethroids for horn fly control include those containing cyfluthrin (Cutter Gold), fenvalerate (including Ear Tag Plus, Ectrin, Insecta-Shield, Starbar, and Vet Shack), flucythrinate (Guardian), lambda-cyhalothrin (Excalibur and Saber Extra), permethrin (including Apollo, Atroban Extra, Deckem, Ear Force, Expar Extra, GardStar, Insecta-Gard, and Permectrin), and zeta-cypermethrin (PYthon and ZetaGard). Ear Force Ranger and Max-Con tags contain a pyrethroid and an organophosphate; but, because it is primarily the pyrethroid compo- | | |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Ear tag or ear tape (cont.) | nent that makes these tags effective, they should be considered very similar to other pyrethroid tags. Double-Barrel tags contain an organophosphate (pirimiphos-methyl) and a pyrethroid (lambda-cyhalothrin).<br><br>Tags containing the organophosphates diazinon (OPtimizer, Patriot, and Terminator tags), ethion (Commando), fenthion (Cutter Blue tags), pirimiphosmethyl (Dominator, Rotator, and Tomahawk tags), or a combination of diazinon and chlorpyrifos (Diaphos and Warrior tags) effectively control horn flies (including pyrethroid-resistant horn flies), but they are somewhat less effective than pyrethroid tags for face fly control. They provide horn fly control for about 8 to 16 weeks. Attach tags in late May or early June after fly populations have begun to increase. Remove tags in September or October. Although organophosphate tags are currently effective against the horn fly in Illinois, resistance to diazinon has been documented in the southern plains. The management practice most likely to slow the development of horn fly resistance to the organophosphates used in ear tags is the avoidance of widespread reliance on such tags for pasture fly control. Do not use organophosphate tags repeatedly for more than two successive seasons. Where practical, use dust bags, oilers, or sprays containing insecticides other than those in ear tags; using feed additives or boluses is another (though less effective) alternative. | | |
| | | cyfluthrin 10% tag (Cutter Gold or Cylence) | 2 tags/animal. | 0 days. Remove in fall or before slaughter. |
| | | beta-cyfluthrin 8% tag (Cylence Ultra) | 2 tags/animal. | 0 days. Remove in fall or before slaughter. |
| | | lambda-cyhalothrin 10% plus PBO 13% tag (Excalibur or Saber Extra) | 2 tags/animal. | 0 days. Do not apply to lactating dairy cattle. Remove in fall or before slaughter. |
| | | coumaphos 20% plus diazinon 20% tag (Co-Ral Plus) | 2 tags/animal. | 0 days. Remove in fall or before slaughter. |
| | | lambda-cyhalothrin 6.8% plus pirimiphos-methyl 14% tag (Double-Barrel) | 2 tags/animal. | 0 days. Do not apply to lactating dairy cattle. Remove in fall or before slaughter. |
| | | cypermethrin or zeta-cypermethrin 10% plus 20% PBO tags (PYthon, PYthon Magnum, or ZetaGard) | 1 to 2 tags/animal. | 0 days. Remove in fall or before slaughter. |
| | | See preceding text for comments on other pyrethroid tags. | | |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Ear tag or ear tape (cont.) | diazinon 20% tag (BovaGard, OPtimizer, or Terminator) | 2 tags/animal. | 0 days. Do not apply to calves less than 3 months old or to lactating dairy cattle. Remove in fall or before slaughter. |
| | | diazinon 20% calf tag (OPtimizer-calf) | 2 tags/animal. | 0 days. (This is a lightweight tag specifically for calves.) Do not apply to lactating dairy cattle. Remove in fall or before slaughter. |
| | | diazinon 30% plus chlorpyrifos 10% tag (Diaphos and Warrior) | 1 to 2 tags/animal. | 0 days. Do not apply to calves less than 3 months old or to lactating dairy cattle. Remove in fall or before slaughter. |
| | | diazinon 40% tag (Patriot) | 1 tag/animal. | 0 days. Do not apply to calves less than 3 months old or to lactating dairy cattle. Remove in fall or before slaughter. |
| | | ethion 36% tag (Commando) | 2 tags/animal. | 0 days. Apply to mature animals. Remove in fall or before slaughter. May be used on lactating dairy cattle. |
| | | fenthion 20% tag (Cutter Blue) | 2 tags/animal. | 0 days. Apply to mature animals. Remove in fall or before slaughter. May be used on lactating dairy cattle. |
| | | pirimiphos-methyl 20% tag (Dominator, Rotator, or Tomahawk) | 2 tags/animal. | 0 days. Do not apply to lactating dairy cattle. Remove in fall or before slaughter. |
| | Spray | Sprays directed to animals should not contaminate feed or water. Do not use sprays containing permethrin to control resistant horn flies that are not controlled by pyrethroid ear tags. | | |
| | | Co-Ral 11.6%EC or 25%WP (coumaphos) | 2 qt 11.6%EC or 2 lb 25%WP/100 gal. water. Completely wet skin to runoff. | 0 days. Do not apply to dairy cattle within 14 days of freshening. |
| | | Vapona 40.4%EC (dichlorvos) | 1 gal./50 gal. water. Use 1 to 2 fl oz/animal/day. | 1 day. Do not contaminate feed or water. Do not wet skin. Do not apply to Brahman or Brahman-cross cattle. Do not apply to calves less than 6 months old. Do not use in conjunction with trichlorfon or other organophosphates. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Spray (cont.) | Delnav 15%EC or 30%EC (dioxathion) | 1 qt 15%EC or 1 pt 30%EC/25 gal. water. | 0 days. Do not use more often than every 14 days. Do not use on dairy cattle or in dairy barns. Restricted use. |
| | | malathion 57%EC | 6 fl oz/5 gal. water. Use 1 to 2 qt/animal. | 0 days. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/100 gal. water. Thoroughly wet animals. | Repeat as needed but not more often than once every 14 days. |
| | | Elector 2.46% (spinosad) | 20 fl oz/10 gal. water. | 2 days. Do not apply more often than weekly or more than 5 consecutive times. |
| | | GardStar 40%EC (permethrin) | 4 fl oz/50 gal. water. Use 1 qt/animal. | 0 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Atroban, Expar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for control of pasture flies on cattle. Check product labels for dilution and application rates.) | | |
| | | DelPhos 11.6%EC (phosmet) | 1 qt/50 gal. water. Apply to thoroughly wet skin. | 3 days. Do not apply in conjunction with other organophosphates or to sick or convalescing animals or to calves less than 3 months old. Do not apply to dairy cattle within 28 days of freshening. |
| | | Ravap 28.7%EC (stirofos plus dichlorvos) | 1 gal./75 gal. water. Use 0.5 to 1 gal./animal. | 0 days. Repeat as needed but not more often than once every 10 days. Do not apply to Brahman or Brahman-cross cattle. Do not apply to calves less than 6 months old. Do not use in conjunction with trichlorfon or other organophosphates. |
| | Pour-on | Cylence 1% (cyfluthrin) | Ready to use. | 0 days. Follow label directions. |
| | | Ivomec 0.5% (ivermectin) | Ready to use. Apply 5 ml/100 lb body weight. | 48 days. Do not use on dairy cattle of breeding age. Effective for 28 days. |
| | | Cydectin (moxidectin) | See label. | 0 days. |

**Table 2. Pest control for beef cattle and nonlactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Pour-on (cont.) | Dectomax (doramectin) | See label. | 45 days. |
| | | Elector 2.46% (spinosad) | Ready to use. Apply 4 ml/110 lb body weight. | 2 days. Do not apply more often than every 14 days or more than 5 consecutive times. |
| | | Eprinex (eprinomectrin) | 1 ml/22 lb | 0 days. |
| | | Saber 1% (lamda-cyhalothrin) | 10 to 15 ml/animal. | 0 days. |
| | | Brute 10% or Permectrin 10%CD (permethrin) | 1.5 ml/100 lb body weight. Do not exceed 15 ml/animal. | 0 days. Permectrin CDS and Boss also may be used for face fly and horn fly control. See product labels. |
| | | Lysoff 8% (fenthion) | See label. | 21 to 35 days. Do not apply to dairy cattle within 28 days of freshening. |
| | | Tiguvon 3% (fenthion) | See label. | 35 to 45 days. Do not apply to dairy cattle within 28 days of freshening. |
| | Trap | Large "walk-through" fly traps positioned at pasture gates (where animals must pass through the traps regularly) can reduce horn fly numbers by up to 70%. No insecticides are used in these traps. Additional information and plans for construction of these traps are available from the Department of Crop Sciences, 1102 S. Goodwin Ave., Urbana, IL 61801 (Attn: R. Weinzierl). See comments on page 155 regarding the Epps trap. This trap can reduce numbers of stable flies, horse flies, and deer flies. | | |

**Table 3. Pest control for lactating dairy cattle**

Insecticides listed in this table are registered for use on lactating dairy cattle. Most insecticides listed for use on beef cattle may be applied to nonlactating dairy cattle if the specified interval between application and freshening is observed. Follow all label directions.

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE** 1/16 to 1/8 inch long. Biting lice are reddish, flattened, and active. Sucking lice are gray to blue and sluggish. Heavy populations cause reduced milk production and anemia. Symptoms are rough, patchy hair coats and a dirty appearance. Lice are most troublesome in winter. | Dust bag | Place dust bags at milkroom exits. Keep bags charged and dry, and service at least once per month. (Co-Ral 1% dust and Ectiban and Permectrin 0.25% dusts may be used for direct hand-dusting; follow label directions.) | | |
| | | Co-Ral 1%D (coumaphos) | Ready to use. | 0 days. |
| | | Ectiban or Permectrin 0.25%D (permethrin) | Ready to use. | 0 days. |
| | Spray | Apply sufficient spray to thoroughly wet each animal; use up to 1 gallon finished spray per animal. Do not contaminate feed, water, milk, or milking equipment. | | |
| | | Elector 2.46% (spinosad) | 20 fl oz/10 gal. water | 2 days. No withholding period for milk. Do not apply more often than weekly or more than 5 consecutive times. |
| | | Taktic 12.5%EC (amitraz) | 760 ml/50 to 100 gal. water. Use up to 2 gal./fully grown animal. | 0 days. Apply spray within 6 hours after mixing. Repeat application in 10 to 14 days. |
| | | Co-Ral 11.6%EC or 25%WP (coumaphos) | 1 qt 11.6%EC or 1 lb 25%WP/100 gal. water. | 0 days. Do not treat calves less than 3 months old. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/100 gal. water. | 0 days. Repeat application 14 to 21 days after first treatment. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Atroban, Expar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for the control of lice on dairy cattle. Check product labels for dilution and application rates.) | | |
| | | Ravap 8.7%EC (stirofos plus dichlorvos) | 1 gal./200 gal. water. Use up to 2 qt/animal. | 0 days. Do not apply to calves less than 6 months old. Do not apply to teats of lactating animals. |
| | Pour-on | Elector 2.46% (spinosad) | Ready to use. Apply 4 ml/110 lb body weight. | 2 days. No withholding period for milk. Do not apply more often than every 14 days or more than 5 consecutive times. |

**Table 3. Pest control for lactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE (CONT.)** | Pour-on (cont.) | Cylence 1% (cyfluthrin) | Ready to use. | 0 days. |
| | | Atroban DeLice or Expar 1% (permethrin) | 0.5 fl oz/100 lb body weight. Do not exceed 5 fl oz/animal. | 0 days. |
| | | Brute 10% or Permectrin 10%CD (permethrin) | Ready to use. 1.5 ml/100 lb body weight. Do not exceed 15 ml/animal. | 0 days. Permectrin CDS also may be used for louse control; see product label. |
| | | Eprinex (eprinomectin) | 1 ml/22 lb. | 0 days. |
| | | Cydectin (moxidectin) | See label. | 0 days. |
| **CATTLE GRUBS** | Pour-on | Eprinex (eprinomectin) | 1 ml/22 lb. | 0 days. See comments on page 167 regarding timing of grub control. |
| | | Cydectin (moxidectin) | See label. | 0 days. See comments on page 167 regarding timing of grub control. |
| **MANGE MITES** Microscopic mites live on or within skin. Lesions vary with mite species. Infestations are greatest in cattle crowded in shelters during winter. | Mange caused by chorioptic mites (barn itch mites) is the most common mite-induced disorder of Illinois dairy cattle. Infested cattle may or may not develop lesions; lesions usually appear as localized nodules that exude serum. Lesions are most prevalent from the tailhead to the hind heels. Insecticides listed for louse control on dairy cattle also control chorioptic mange. Cattle scabies (psoroptic mange) is a quarantinable disease. Its symptoms are lesions that occur first at the withers, over the back, and at the tailhead. The wounds itch, and rubbing leads to abscesses, especially on the shoulders and rump. Mites move to edges of scabs, causing lesions to enlarge and coalesce. Scabs may cover much of the body. Accurate diagnosis requires microscopic examination of skin scrapings. Where cattle scabies is detected, contact the Illinois Department of Agriculture, Bureau of Animal Health, Illinois State Fairgrounds, Springfield, IL 62706; (217)782-4944. | | | |
| **TICKS** Eight-legged adults of most species are reddish brown and less than ¼ inch long. Engorged females may exceed ½ inch in length. Ticks are blood feeders and disease vectors. | Ticks are rarely economically important on Illinois dairy cattle. Problems are most likely where cattle graze in brushy or wooded areas. | | | |
| | Spray | Taktic 12.5%EC (amitraz) | 1 qt/100 gal. water. Use up to 2 gal./fully grown animal. | 0 days. Apply spray within 6 hours after mixing. Repeat application in 10 to 14 days. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 to 2 qt/animal. | 0 days. Do not apply more often than once every 14 days. |
| | (Additional permethrin formulations—including emulsifiable concentrates of Atroban, Expar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for the control of ticks on dairy cattle. Check product labels for dilution and application rates.) | | | |

**Table 3. Pest control for lactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **MOSQUITOES** Blood feeding. Annoyance may cause cattle to remain in buildings and reduce their grazing. | Mosquito populations are greatest near low, wet areas; ponds; and slow-moving streams. Reduction of mosquito-breeding sites is necessary for long-term control. For information on source reduction and area treatments, see *Mosquitoes in Illinois: Recommendations for Prevention and Control,* an annually revised publication available from the Illinois Department of Public Health in Springfield. The following insecticides provide some short-term relief for treated animals, but frequent applications are not economical or recommended. | | | |
| | Spray (to animals) | Vapona 40.2%EC (dichlorvos) | 1 qt/12.5 gal. water. Mist 1 to 2 fl oz/animal/day. | 1 day. Do not wet skin. Do not contaminate feed, water, milk, or milking equipment. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 to 2 qt/animal. | 0 days. Do not apply more often than every 14 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for the control of mosquitoes on dairy cattle. Check product labels for dilution and application rates.) | | |
| | | GardStar 40%EC (permethrin) | 4 fl oz/50 gal. water. Use 1 qt/animal. | 0 days. |
| | | pyrethrins (0.03 to 0.10%) plus synergist (0.5 to 1.0%) | Ready to use. Mist 1 to 2 fl oz/animal. | 0 days. Do not wet skin. Do not contaminate feed, water, milk, or milking equipment. Repeat as necessary. |
| **PASTURE FLIES (HORN FLIES, FACE FLIES, STABLE FLIES)** **Horn flies** are smaller than house flies but are similarly colored and marked. They have piercing mouthparts and are blood feeders. Horn flies congregate about the back, shoulders, and horns; on hot days, they are mostly on the shady side of the | **Threshold infestations and adequate levels of control**: In Illinois, control programs that use dust bags or oilers often reduce horn fly infestations to 10 to 50 flies per animal. The use of dust bags or oilers provides adequate and economical control of horn flies and usually does not favor rapid development of insecticide resistance (as do ear tags).<br><br>Available data do not support any estimates of what constitutes an economically damaging number of face flies or an acceptable level of face fly control. Although face flies annoy cattle, even heavy infestations do not cause reductions in milk production. Face flies can transmit the pathogen that causes pinkeye, but pinkeye outbreaks also occur in the absence of face flies.<br><br>Research indicates that as few as 1 to 5 stable flies per leg can reduce milk production in some conditions. Spraying the legs of cattle as they exit the milkroom provides temporary relief, but no long-term control is accomplished.<br><br>Moving cattle into shelters reduces annoyance by horn flies and face flies, but it does not deter stable fly attack. | | | |
| | Back rubber or face rubber (oilers) | Mix insecticides with no. 2 fuel oil, no. 2 diesel fuel, or a label-recommended mineral oil. Mineral oils are less irritating than fuel oils. Do not use waste oil or motor oil. Service the oiler at least once per week. For self-treating devices to be effective, cattle must use them frequently. Place oilers in the entryways | | |

**Table 3. Pest control for lactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** animal or on the belly. Horn flies seldom follow animals into barns or sheds. **Face flies** resemble house flies but are slightly larger and darker. Only females frequently visit cattle. They feed on secretions about the eyes, nose, and mouth. | Back rubber or face rubber (oilers) (cont.) | to be effective, cattle must use them frequently. Place oilers in the entryways to water or mineral feeders or in the milking room exit. Well-used back rubbers or face rubbers control horn flies and provide some face fly control. They do not control stable flies. | | |
| | | Co-Ral 11.6%EC (coumaphos) | 1 gal./13 gal. fuel or mineral oil. | 0 days. |
| | | Ectiban, Hard Hitter, Insectaban, or Insectrin 5.7%EC (permethrin) | 1 qt/10 gal. oil. | 0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags. |
| | | Permectrin II 10%EC (permethrin) | 1 qt/20 gal. fuel or mineral oil. | 0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags. |
| | | Ravap 28.7%EC (stirofos plus dichlorvos) | 1 gal./6 gal. fuel or mineral oil. | 0 days. |
| | Dust bag | For self-treating devices to be effective, cattle must use them regularly. Place dust bags in the entryways to water or mineral feeders or in the milking room exit. Keep dust bags dry; service at least once per week. Dust bags control horn flies and provide some reduction in face fly problems. They do not control stable flies. (Note: Insecticide dusts listed below can also be used for direct hand-dusting; follow label directions.) | | |
| | | Co-Ral 1%D (coumaphos) | 10 lb/dust bag. | 0 days. Do not treat calves less than 3 months old. |
| | | Ectiban, Insectrin, or Permectrin 0.25%D (permethrin) | 10 lb/dust bag. | 0 days. Do not charge self-treating devices with permethrin if the treatment is intended to aid in delaying horn fly resistance to pyrethroids or to control resistant horn flies that are not controlled by pyrethroid ear tags. |
| | | Rabon 3%D (stirofos) | 4 to 8 lb/dust bag. | 0 days. |

**Table 3. Pest control for lactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Spray | It is important that the following sprays do not contaminate feed, water, milk, or milking equipment. Do not use sprays containing fenvalerate or permethrin to control resistant horn flies that are not controlled by pyrethroid ear tags. | | |
| | | Elector 2.46% (spinosad) | 20 fl oz/10 gal. water. | 2 days. No withholding period for milk. Do not apply more often than weekly or more than 5 consecutive times. |
| | | Vapona 23.4%EC or 1%EC oil base (dichlorvos) | 1 qt 23.4%EC/6 gal. water; use 1 to 2 fl oz/animal/day. Or 1%EC (oil base), ready to use; mist 1 to 2 fl oz/animal/day. | 0 days. Do not wet skin. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 to 2 qt/animal. | 0 days. Repeat as needed but not more often than every 14 days. |
| | | GardStar 40%EC (permethrin) | 4 fl oz/50 gal. water. Use 1 qt per animal. | 0 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Atroban, Expar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for pasture fly control on dairy cattle. Check product labels for dilution and application rates.) | | |
| | | pyrethrins (0.1%) plus synergist | Ready to use. Apply 1 to 2 fl oz/animal. | 0 days. Repeat as needed. |
| | Feed additive | Feed additives prevent the development of face fly and horn fly larvae in cattle dung. Stable flies do not develop in fresh dung and are not controlled by feed additives. Face flies and horn flies migrate considerable distances, so larval control in the dung of a single herd may not substantially reduce fly populations if other herds in the area do not also receive boluses or feed additives. Animals must consume the recommended dosage for the feed additive | | |
| | | Altosid or Moorman's IGR 0.02% (methoprene) | 0.25 to 0.5 lb/100 lb body weight/month. | 0 days. Feed mineral mix or blocks from May through August. |
| | | Rabon 7.76% Oral Larvicide (stirofos) | 70 mg a.i./100 lb body weight/day. | 0 days. Feed in complete feeds, concentrates, or protein and mineral supplements from May through August. |

**Table 3. Pest control for lactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Bolus | Boluses release an active ingredient that prevents the development of face fly and horn fly larvae in treated dung. Stable flies do not develop in fresh dung and are not controlled by bolus use. Face flies and horn flies migrate considerable distances, so larval control in dung of a single herd may not substantially reduce fly populations if other herds in the area do not receive boluses or feed additives. | | |
| | | Vigilante 9.7% bolus (diflubenzuron) | 1 bolus/550 to 1,100 lb body weight. | 0 days. Use standard balling gun. Do not administer to animals weighing less than 300 pounds. Use no more than one bolus per animal. Boluses may be divided in half to achieve correct rate. |
| | Ear tag or ear tape | Before widespread development of resistance in the horn fly, ear tags and tapes impregnated with pyrethroid insecticides such as fenvalerate, flucythrinate, and permethrin effectively controlled horn flies and gave some control of face flies infesting pastured cattle. One tag or tape per cow effectively controlled horn flies for up to 20 weeks. However, midseason control failures resulting from horn fly resistance have occurred throughout Illinois in recent years.<br><br>Although Max-Con tags containing cypermethrin (a newer pyrethroid) plus Dursban (an organophosphate) plus a synergist are slightly more effective against resistant horn flies than the original pyrethroid tags, they do not consistently control resistant populations and can be expected to cause an increase in the level of pyrethroid resistance. Pyrethroid tags containing the more active compounds cyfluthrin (Cutter Gold tags), lambda-cyhalothrin (Excalibur and Saber Extra tags), or zeta-cypermethrin (PYthon and ZetaGard tags) have initially controlled pyrethroid-resistant horn flies, but trials conducted in the southeastern United States have shown that these tags also intensify resistance and then fail to provide control. Excalibur and Saber Extra tags are not registered for use on lactating dairy cattle.<br><br>Because resistance has already reduced the performance of pyrethroid tags and tapes, and because continued use of any pyrethroids in such devices is likely to result in even higher levels of resistance (levels that may allow horn fly survival even when pyrethroid sprays or dusts are applied), this publication recommends that cattle producers refrain from using pyrethroid tags or use them only once in every three or four seasons. Tags and tapes that rely on pyrethroids for horn fly control include those containing cyfluthrin (Cutter Gold), cypermethrin (Max-Con), fenvalerate (including Ear Tag Plus, Ectrin, Starbar, and Vet Shack), flucythrinate (Guardian), permethrin (including Apollo, Atroban Extra, Ear Force, Ear Force Ranger, Expar Extra, Fearing Duflex, GardStar, InsectaGard), and zeta-cypermethrin (PYthon and ZetaGard).<br><br>Tags containing the organophosphate ethion (Commando) or fenthion (Cutter Blue) are registered for use on lactating dairy cattle and should control horn flies for 8 to 16 weeks. Use 2 tags per animal. Remove in the fall or before slaughter. The organophosphates diazinon (BovaGard, OPtimizer, Patriot, and Terminator tags) and pirimiphos-methyl (Dominator, Rotator, and Tomahawk tags) should not be used on lactating dairy cattle. | | |

**Table 3. Pest control for lactating dairy cattle (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **PASTURE FLIES (CONT.)** | Pour-on | Elector 2.46% (spinosad) | Ready to use. Apply 4 ml/110 lb body weight. | 2 days. No withholding period for milk. Do not apply more often than every 14 days or more than 5 consecutive times. |
| | | Cylence 1% (cyfluthrin) | Ready to use. | 0 days. |
| | | Permectrin 10% CD (permethrin) | Ready to use. 1.5 ml/100 lb body weight. Do not exceed 15 ml/animal. | 0 days. Permectrin CDS also may be used for horn fly and face fly control. See product label. |
| | | Cydectin (moxidectin) and Eprinex (eprinomectin) used for internal parasites also provide 2 to 4 weeks of horn fly control. | | |

**Table 3. Pest control for hogs**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **MANGE MITES (AND LICE)** | Although mange mites and lice are blamed for substantial losses in swine production, controlled studies indicate that otherwise healthy pigs suffer little or no reduction in the rate of gain or feed efficiency when infested with mange mites and lice. Managing lice and mange mites remains an important step in swine production, but keeping every animal louse free and mange free through the time of sale and slaughter is probably not economically justified. | | | |
| **Microscopic mites** feed on or within skin and cause mange. | Mange mites and lice are spread by direct contact among animals. These pests may survive off the host animal for short periods in bedding, but they do not infest animals other than swine. Prevent mange outbreaks by isolating and treating any new animals—especially boars—before adding them to the herd. (SPF breeding stock are treated and declared free of mange and lice before sale.) Thoroughly clean and disinfect pens before using them to hold uninfested animals. To prevent infestation of newborn pigs, treat boars before the breeding season and treat sows before farrowing. It is often necessary to treat all animals in contact with those infested by mange mites or lice. It is also wise to isolate carrier animals to prevent the unnecessary spread of these pests from animal to animal. | | | |
| **Sarcoptic mange** usually starts at the head and then spreads to the back; infested skin becomes dry, scurfy, or leathery. Rubbing may lead to raw or scabby areas. | The following insecticides help to control sarcoptic mange. There is no satisfactory chemical control for the hog follicle mites that cause demodectic mange. Isolate hogs with demodectic mange. Kill and destroy severely infested animals; market for slaughter the animals that are severely attacked. Clean and disinfect pens, sheds, and other infested areas before moving in uninfested animals. | | | |
| | Follow label precautions against the simultaneous use of organophosphate sprays, dusts, or pour-ons with similar medications used for internal parasite control. Do not contaminate feed or water. | | | |
| | Spray or pour-on | Point-Guard 2% (amitraz) | Ready to use. See comments. | 7 days. Dose varies with size of animal; see label. Apply into each ear and to midline of back. |

**Table 4. Pest control for hogs (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **MANGE MITES (AND LICE) (CONT.)** | Spray or pour-on (cont.) | Taktic 12.5%EC (amitraz) | 1 qt/50 gal. water. Spray animals, bedding, and walls thoroughly. | 3 days. Apply spray within 6 hours after mixing. Repeat application in 7 to 10 days. |
| | | Ectrin 10%WDL (fenvalerate) | 1 qt/50 gal. water. Spray each animal thoroughly. | 1 day. Repeat application in 14 days if necessary. |
| | | lindane 12.4%EC or 20%EC | 3 pt 12.4%EC or 1 qt 20%EC/100 gal. water. Spray animals thoroughly. | 30 days. Treat twice at a 7-day interval. Do not treat pigs less than 3 months old. Do not treat sows within 2 weeks before farrowing or 3 weeks after farrowing. Restricted use. |
| | | malathion 57%EC | 1 qt/15 gal. water. Treat animals, bedding, and walls thoroughly. | Do not treat pigs less than 1 month old. Repeat treatment after 10 days. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/25 gal. water. Spray animals thoroughly. | 5 days. Repeat application after 14 days. |
| | | GardStar 40%EC (permethrin) | 4 fl oz/25 gal. water. Spray animals thoroughly. | 5 days. Repeat application after 14 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Atroban, Expar, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for control of hog lice and mange. Check product labels for dilution and application rates.) | | |
| | | Prolate or DelPhos 11.6%EC (phosmet) | 2 qt/50 gal. water. Treat animals thoroughly. | 1 day. Do not treat pigs less than 3 months old. |
| | Dust | malathion 4 to 5%D | Thoroughly cover animals more than 1 month old. Also treat pens and bedding. Use 0.25 to 0.5 tbsp/pig for pigs less than 1 month old. | 0 days. Repeat as needed. Gives only partial control of mange mites. |
| | Injection | Ivomec 0.27% or 1% (ivermectin) | See label. | 18 days. Inject subcutaneously. Use aseptic procedures. |
| | | Dectomax (doramectin) | See label. | 24 days. |

**Table 4. Pest control for hogs (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE** Up to 1/16 inch long. Hog lice are bluish black in color. They suck blood from infested animals. | | **Insecticides listed for controlling mange mites on hogs also control lice.** Do not contaminate feed or water. Follow label precautions against the simultaneous use of organophosphate sprays, dusts, or pour-ons with medications used for internal parasite control. | | |
| | Spray | Co-Ral 25%WP (coumaphos) | 2 lb/100 gal. water. Spray each animal thoroughly. | 0 days. Do not treat animals less than 90 days old. Apply a second spray 10 to 14 days after the first. |
| | Dust | Co-Ral 1%D (coumaphos) | 1 oz/animal. See label. | 0 days. Dust especially around shoulders and back. Repeat as needed but not more than once every 10 days. |
| | | Ectiban, Insectrin, or Permectrin 0.25%D (permethrin) | | 5 days. Make a second application 14 days after the first. |
| | | Rabon 3%D (stirofos) | 3 to 4 oz/animal; 1 lb/150 sq ft of bedding for severe infestations. | 0 days. Do not re-treat for 14 days. |
| | Pour-on | Tiguvon 3% Pour-On (fenthion) | 0.5 fl oz/100 lb body weight. | 14 days. May be used on gestating and lactating sows. Do not re-treat within 35 days. |
| | | Ectrin 10%WDL (fenvalerate) | 1 qt/25 gal. water. Pour 4 fl oz/animal on head and back midline. | 1 day. Add wetting agent according to label directions. Repeat application in 14 days if necessary. |
| | Spray or pour-on | Point-Guard 2% (amitraz) | Ready to use. See comments. | 7 days. Dose varies with size of animal; see label. Apply into each ear and to midline of back. |
| | Feed additive | Ivomec 0.01% or 0.02% (ivermectin) | See label. | 5 to 18 days. |

**Table 5. Pest control for sheep**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **KEDS, LICE**<br><br>**Sheep keds** (also called sheep ticks) are flattened, wingless, reddish brown flies about the size of house flies.<br><br>**Lice** reach 1/16 to 1/8 inch in length. Biting lice are flattened and yellowish to reddish in color. Sucking lice are oval and bluish gray. | Spray | Apply enough spray to thoroughly cover each animal. Do not contaminate feed or water. | | |
| | | Co-Ral 25%WP (coumaphos) | *Lice:* 2 lb/100 gal. water. *Keds:* 4 lb/100 gal. water. | 15 days. Do not treat lambs less than 3 months old. |
| | | Dryzon 50%WP and other trade names (diazinon) | 0.5 lb/100 gal. water. Use 1 gal./animal. | 14 days. Use high pressure and volume. Do not treat lambs less than 2 weeks old. |
| | | Ectrin 10%WDL (fenvalerate) | 1 qt/100 gal. water. Wet each animal with up to 1 qt of spray. | 2 days. Repeat application in 30 days if necessary. Do not apply more than twice in the spring and twice in the fall. |
| | | malathion 57%EC | 1 gal./100 gal. water. | 0 days. Do not treat lambs less than 1 month old. |
| | | Ectiban, Hard Hitter, or Insectaban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 to 2 qt/animal. | 0 days. Repeat application in 14 days. Do not treat more often than every 14 days. |
| | Dip | Co-Ral 25%WP (coumaphos) | *Lice:* 2 lb/100 gal. water. *Keds:* 4 lb/100 gal. water. | 15 days. Do not dip lambs less than 3 months old. |
| | | Del-Tox 20.4%EC (dioxathion) | 2 qt/100 gal. water. | 0 days. Do not dip lambs less than 3 months old or sick, convalescent, or stressed animals. Prevent ingestion of dip. Dioxathion is available in additional formulations, including Co-Nav, a restricted-use product. |
| | Dust | Co-Ral 1%D (coumaphos) | Follow label directions. | 15 days. Treat once after shearing. Do not treat lambs less than 3 months old. |
| | | diazinon 2%D | 1.5 oz/animal. | 14 days. Do not treat lambs less than 2 weeks old. |
| | | malathion 4 to 5%D | 1 to 2 oz/animal. | 0 days. Repeat application in 2 to 3 weeks if needed. Do not treat lambs less than 1 month old. |
| | | PYthon 0.5%D (zeta-cypermethrin) | 2 oz/animal. | 0 days. Use as needed but not more often than every 3 days. |

**Table 5. Pest control for sheep (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **KEDS, LICE (CONT.)** | Pour-on | Ectrin 10%WDL (fenvalerate) | 2 qt/25 gal. water. Pour 4 fl oz/animal down midline of back. | 2 days. Add wetting agent according to label directions. Repeat application in 30 days if necessary. Do not apply more than twice in the spring and twice in the fall. |
| | | Atroban DeLice or Expar 1% (permethrin) | Up to 3 fl oz per animal (depending on weight). Pour on midline of back. | 0 days. Make a second application 14 days after the first. |
| **NASAL BOTS** | Oral drench | Ivomec 0.08% solution (ivermectin) | 3 ml/26 lb body weight. | 11 days. Administer orally. |
| **WOOL MAGGOTS** Cream-colored maggots are larvae of blow flies. Maggots live in wet, matted wool near the rear of the animal and in matted wool surrounding wounds. | | Reduce wool maggot attacks by tagging sheep (shearing under the tail and between the hind legs), docking, and castrating before May. Practice good sanitation. Shear around and direct sprays to the infested areas. | | |
| | Spray | Co-Ral 25%WP (coumaphos) | 4 lb/100 gal. water. Use 1 gal./animal. | 15 days. Do not treat lambs less than 3 months old. |
| | | Catron IV 0.5% aerosol (permethrin) | Spray wound thoroughly. | 0 days. Reapply every 5 to 7 days. |
| **SCAB MITES (SCABIES, WET MANGE)** | Sheep scab is a quarantinable disease. Infested animals shed wool; skin becomes roughened and crusted. Where infestations are suspected, contact the Illinois Department of Agriculture, Bureau of Animal Health, Illinois State Fairgrounds, Springfield, IL 62706; (217)782-4944. | | | |
| **HORN FLIES, FACE FLIES** | Spray | Co-Ral 25%WP (coumaphos) | 2 lb/100 gal. water. | 15 days. Do not treat lambs less than 3 months old. |
| | | Ectiban, Hard Hitter, or Insectaban 5.7%EC (permethrin) | 1 qt/25 gal. water. Apply 1 to 2 qt/animal. | 0 days. Do not treat more often than every 14 days. |
| | | pyrethrins (0.05 to 0.10%) plus synergist (0.5 to 1.0%) | 1 to 2 fl oz/animal. | 0 days. Apply daily to head, neck, and front legs as a fine mist. Do not wet hair or skin. |

**Table 6. Pest control for goats**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE** | Spray | Ectrin 10%WDL (fenvalerate) | 1 qt/100 gal. water. Wet each animal with up to 1 qt of spray. | 2 days. Do not apply to lactating goats. Repeat application in 30 days if necessary. Do not apply more than twice in the spring and twice in the fall. |
| | Pour-on | Ectrin 10%WDL (fenvalerate) | 1 qt/25 gal. water. Pour 4 fl oz/animal down midline of back. | 2 days. Do not apply to lactating goats. Add wetting agent according to label directions. Repeat application in 30 days if necessary. Do not apply more than twice in the spring and twice in the fall. |
| **FACE FLIES, HORN FLIES, STABLE FLIES, HORSE FLIES, DEER FLIES** | Spray | pyrethrins (0.05 to 0.10%) plus synergist (0.5 to 1.0%) | 1 to 2 fl oz/animal. | 0 days. Apply to head, neck, and front legs as a fine mist. Do not wet hair or skin. |

**Table 7. Pest control for poultry**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE, NORTHERN FOWL MITES (BIRD TREATMENT)** | Spray | Sevin 50%WP or 80%SP (carbaryl) | 6 oz 50%WP or 4 oz 80%SP/5 gal. water. Use 1 gal./100 birds. | 7 days. Repeat treatment in 4 weeks if necessary. |
| **Chicken lice** are flat-bodied, straw-colored, 1/16-inch-long lice with chewing mouthparts. They feed on feathers and skin flakes, irritating birds. Severe infestations reduce egg production. | | Co-Ral 25%WP (coumaphos) | *Lice:* 6 oz/5 gal. water. *Mites:* 3 oz/5 gal. water. Use 1 gal./100 to 125 birds, or 0.5 fl oz/bird. | 0 days. Do not treat more than once per week. Do not treat within 10 days of vaccination or stress. Treat vent area thoroughly. |
| | | malathion 57%EC | 1 fl oz/1 gal. water. Use 1 gal./100 to 125 birds. | 0 days. Repeat treatment in 4 to 8 weeks or when necessary. |
| | | Atroban, Expar, Permaban 11%EC, or Permectrin II 10%EC (permethrin) | 1 qt/50 gal. water. Use 1 gal./100 birds. | 0 days. Treat vent area thoroughly. |

**Table 7. Pest control for poultry (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE, NORTHERN FOWL MITES (BIRD TREATMENT) (CONT.)** Northern fowl mites are dark red to black blood feeders that build up in the vent area. Mature mites are roughly 1/25 inch long. Feathers around the vent appear grayish or black from accumulation of mites, mite eggs, and excrement. Severe infestations reduce egg production and can cause death. Northern fowl mites are most troublesome in winter. | Spray (cont.) | Ectiban, Hard Hitter, or Insectaban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 gal./100 birds. | 0 days. Treat vent area thoroughly. |
| | | GardStar 40%EC (permethrin) | 4 to 16 fl oz/15 gal. water. | 0 days. Treat vent area thoroughly. |
| | | Ravap 28.7%EC (stirofos plus dichlorvos) | 1 gal/50 gal. water. Use 1 to 2 gal./100 birds and 1 to 2 gal./1,000 sq ft of litter. | 0 days. Do not apply more often than every 14 days. |
| | Dust | Sevin 5%D (carbaryl) | Use 1 lb/100 birds. | 7 days. Apply with shaker or hand duster. Do not treat more than once every 4 weeks. |
| | | malathion 4 to 5%D | Use 1 lb/100 birds. | 0 days. Apply with shaker or hand duster. |
| | | Ectiban or Permectrin 0.25%D (permethrin) | Use 1 lb/100 birds. | 0 days. Apply with shaker or hand duster. Treat vent area thoroughly. |
| | | Rabon 3%D (stirofos) | Use 1 lb/300 birds. | 0 days. Apply with hand or power duster. Do not treat more than once every 14 days. |
| | Strip | Permectrin 10% strip (permethrin) | 1 or 2 strips per cage of up to 9 hens. | 0 days. For northern fowl mite control. |
| **LICE, CHICKEN MITES, NORTHERN FOWL MITES (POULTRY HOUSE AND LITTER TREATMENT)** **Chicken mites** (or roost mites) are bright to dark red and 1/25 inch long. They hide in cracks and crevices during the day and feed on birds at night. | Spray | Sevin 50%WP or 80%SP (carbaryl) | 2 lb 50%WP or 1.5 lb 80%SP/5 gal. water. Use 1 to 2 gal./1,000 sq ft. | 7 days. Apply spray to walls, bedding, litter, and roosts. Force spray into cracks and crevices. Repeat as needed. Avoid contamination of nests, eggs, feed, and water. |
| | | Co-Ral 25%WP (coumaphos) | 6 oz/5 gal. water. Use 1 gal./1,000 sq ft. | 0 days. Apply thoroughly to litter, walls, ceilings, floors, roosts, nests, and adjacent areas. Force spray into cracks and crevices. |
| | | malathion 57%EC | 2 fl oz/gal. water. Use 1 gal./1,000 sq ft. | 0 days. Apply thoroughly to litter, walls, ceilings, floors, roosts, nests, and adjacent areas. Force spray into cracks and crevices. |

**Table 7. Pest control for poultry (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **LICE, CHICKEN MITES, NORTHERN FOWL MITES (POULTRY HOUSE AND LITTER TREATMENT) (CONT.)** | Spray (cont.) | Ravap 28.7%EC (stirofos plus dichlorvos) | 1 gal./25 gal. water. Use 1 pt/100 sq ft. | 0 days. Apply to roost areas with brush or spray. |
| **Chicken mites (cont.)** They are most prevalent in spring, summer, and fall, not in winter. | Dust | Sevin 5%D (carbaryl) | 1 lb/40 sq ft. | 7 days. Apply to litter, roosts, and adjacent areas. Do not apply to eggs or nests. Do not treat more than once every 4 weeks. |
| | | malathion 4 to 5%D | 1 lb/50 to 60 sq ft. | 0 days. Apply liberally to litter, walls, ceilings, roosts, nests, and adjacent areas. |
| | | Rabon 3%D (stirofos) | 1 lb 3%D/100 sq ft. | 0 days. Treat litter evenly and thoroughly. |
| **DARKLING BEETLES (LESSER MEALWORMS) AND HIDE BEETLES** Cream-colored larvae infest decaying organic matter or moldy feeds. Can serve as intermediate hosts for poultry pathogens. Sometimes nest in and damage building insulation or wood. | Spray | Sevin 80%SP or 40% or 43.4% suspensions (carbaryl) | 62.5 lb 80%SP or 50 qt 40% or 43.4% suspensions/100 gal. water. Use 2 gal./1,000 sq ft. | 7 days. Apply evenly and thoroughly to litter or floor surface. Do not apply directly to poultry, nests, or eggs. Repeat as needed. |
| | | Safecide 99%IC (orthoboric acid) | 1 to 2 lb/3 gal. water. Use 3 gal./100 sq ft. | Remove birds before application. |
| | Dust | Sevin 5%D (carbaryl) | 1 lb/40 sq ft. | 7 days. Do not apply to eggs or nest litter. Do not treat more than once every 4 weeks. |
| | | Safecide 99%IC (orthoboric acid) | 1 to 2 lb/100 sq ft. | Remove birds before application. |
| | | (Additional dusts registered by the USEPA to control mealworms include Littershield [obstirofos plus diatomaceous earth] and Red Zone. See product labels for application methods and rates.) | | |
| | Bait | Safecide 30% Bait (orthoboric acid) | 1 to 2 lb/100 sq ft. Apply to floor. | Where birds are grown on litter, remove birds before application. Removal is not required where birds are held in cages. |
| **BED BUGS** Flat, reddish brown, blood-sucking insects that feed at night. Rarely seen on birds during daylight. | Spray | Sevin 50%WP, 80%SP, or 40% or 43.4% suspensions (carbaryl) | 8 lb 50%WP, 5 lb 80%SP, or 4 qt 40% or 43.4% suspensions/100 gal. water. Use 1 to 2 gal./1,000 sq ft. | 7 days. Apply thoroughly to walls, litter, and roost surfaces. Force spray into cracks and crevices. Do not apply directly to poultry, nests, or eggs. Repeat as needed. |

**Table 7. Pest control for poultry (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **BED BUGS (CONT.)** | Spray (cont.) | GardStar 40%EC (permethrin) | 4 fl oz/10 gal. water. | 0 days. Spray crevices in roost poles, cracks in walls, and nest boxes. |
| | Dust | Sevin 5%D (carbaryl) | 1 lb/40 sq ft. | 7 days. Apply evenly to litter. Do not treat more than once every 4 weeks. Do not apply to eggs or nest. |

**Table 8. Pest control for horses**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **MANGE MITES** Burrowing in skin causes pain and itching. Most prevalent in winter. | Spray | Ectiban, Hard Hitter, or Insectaban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 to 2 qt/animal. | 0 days. Repeat application in 14 days. Do not treat more often than every 14 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of GardStar, Insectrin, Permaban, and Permectrin II—are registered for the control of mites on horses. Check product labels for dilution and application rates.) | | |
| **LICE** 1/16 to 1/8 inch in length. Biting lice are yellow to red. Sucking lice are brownish to blue–gray. Head and neck, withers, and tailhead develop a scurfy appearance. Rubbing may create raw areas. | Spray | Co-Ral 25%WP or 11.6%EC (coumaphos) | 0.5 lb 25%WP or 1 pt 11.6%EC/25 gal. water. Treat animal thoroughly. | 0 days. |
| | | malathion 57%EC | 6.5 to 10 fl oz 57%EC or 0.75 lb 25%WP/5 gal. water. Treat animal thoroughly. | 0 days. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 to 2 qt/animal. | 0 days. Repeat application in 14 days. Do not treat more often than every 14 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of GardStar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for the control of lice on horses. Check product labels for dilution and application rates.) | | |

**Table 8. Pest control for horses (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **TICKS** Seldom a problem unless horses graze in brushy or wooded areas. | Spray | Co-Ral 25%WP or 11.6%EC (coumaphos) | 1 lb 25%WP or 1 qt 11.6%EC/25 gal. water. Treat animal thoroughly. | 0 days. Repeat as necessary. |
| | | malathion 57%EC or 25%WP | 6.5 to 10 fl oz 57%EC or 0.75 lb 25%WP/5 gal. water. Treat animal thoroughly. | 0 days. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 to 2 qt/animal. | 0 days. Do not treat more often than every 14 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of GardStar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for the control of ticks on horses. Check product labels for dilution and application rates.) | | |
| **HORSE BOTS** Flies are nearly as large as honey bees. They deposit eggs on the forelegs, throat, and muzzle area; fly activity severely annoys horses. Eggs are ingested; larvae (bots) develop within the horse's alimentary canal. Treat after hard freeze. | Feed additive | Anthon 90% powder (trichlorfon) | 5 g/250 lb body weight, mixed with feed. Treat from mid-October to mid-December. | Nonfood use. Repeat after 3 to 4 months. Withdraw all feed 12 to 18 hours prior to and 3 hours after treatment. Do not treat colts under 4 months of age, mares in the last month of gestation, or horses to be used for food. |
| | Oral paste | Eqvalan 1.87% (ivermectin) | Ready to use. Follow directions on prefilled tube. | Nonfood use. Other ivermectin products registered for this use include Agri-mectin, Equimectrin, Rotectin, and Zimectrin |
| | | Equibot, Combot, Anthon, or Dyrex (trichlorfon) | Ready to use. Follow directions on prefilled syringe. | Nonfood use. |
| | | Quest 2% gel (moxidectin) | 0.4 mg/kg (2.2 lbs) body weight. | Nonfood use. |
| | Stomach tube | Consult with a veterinarian for treatment with carbon disulfide or with piperazine + carbon disulfide (Parvex Plus). | | |
| | Preventive spray | malathion 57%EC | During fall months, sponge legs, under jaw, and chest of animal with a warm, 0.5% malathion solution. | 0 days. Eggs will be stimulated to hatch and the larvae will be prevented from burrowing into the animal. Re-treat when more eggs accumulate. Do not use bare hands; use specially prepared gloves or rubber gloves. |

**Table 8. Pest control for horses (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **SCREWWORMS, BLOW FLIES** Maggots develop in wounds. | Spray | Co-Ral 3% Spray Foam (coumaphos) | Ready to use. Spray thoroughly so that foam completely covers wound. | 0 days. |
| | | Co-Ral 25%WP (coumaphos) | 1.3 oz/gal. water. Treat wound lightly but thoroughly. | 0 days. |
| | Dust | Co-Ral 5%D (coumaphos) | Ready to use. Treat wound lightly but thoroughly. | 0 days. |
| **HORN FLIES, FACE FLIES, STABLE FLIES, HORSE FLIES, DEER FLIES, BLACK FLIES, MOSQUITOES** | Spray | Co-Ral 25%WP or 11.6%EC (coumaphos) | 0.5 lb 25%WP or 1 pt 11.6%EC/25 gal. water. Treat animal thoroughly. | 0 days. |
| | | BiteFree or Tri-Tec 14 (cypermethrin plus pyrethrins) | Ready to use. Apply as mist spray; follow label directions. | Do not treat animals intended for slaughter. |
| | | Ectrin 10%WDL (fenvalerate) | 4 fl oz/3 gal. water. Mist 8 fl oz spray per animal. Direct at face, head, shoulders, and legs. | Do not treat animals intended for slaughter. |
| | | malathion 57%EC or 25%WP | 6.5 to 10 fl oz 57%EC or 0.75 to 1.25 lb 25%WP/ 5 gal. water. Treat animal thoroughly. | 0 days. |
| | | Ectiban 5.7%EC (permethrin) | 1 qt/25 gal. water. Use 1 to 2 qt/animal. | 0 days. Do not treat more often than every 14 days. |
| | | GardStar 40%EC (permethrin) | 2 fl oz/gal. water. | 0 days. |
| | | (Additional permethrin formulations—including emulsifiable concentrates of Atroban, Expar, Hard Hitter, Insectaban, Insectrin, Permaban, and Permectrin II—are registered for the control of biting flies on horses. Check product labels for dilution and application rates.) | | |
| | | pyrethrins plus synergist | Ready to use. | 0 days. Apply as a mist spray. Do not wet the hide. Repeat as needed. |

**Table 8. Pest control for horses (cont.)**

| Pest | Treatment method | Insecticide and formulation | Dilution and rate | Preslaughter interval, restrictions, comments |
|---|---|---|---|---|
| **HORN FLIES, FACE FLIES, STABLE FLIES, HORSE FLIES, DEER FLIES, BLACK FLIES, MOSQUITOES (CONT.)** | Spray (cont.) | Rabon 1% Spray-n-Wipe (stirofos) | Apply 1 to 2 fl oz to flanks, belly, and back. | 0 days. |
| | Dust | Co-Ral 1%D (coumaphos) | 2 oz/animal. | 0 days. Apply to the head, neck, shoulders, back, and tailhead. Repeat as needed. |
| | | malathion 4%D | 4 tbsp/animal. | 0 days. Apply evenly along back line. Repeat at 10- to 14-day intervals. |
| | Wipe-on | Rabon 2% Gel Wipe-on (stirofos) | 1 to 2 fl oz/animal. | 0 days. Apply as directed every 2 to 3 days if needed. |

**Table 9. Major classes of insecticides and active ingredients registered for one or more uses on or around livestock**

| Class of insecticide | Common names of active ingredients |
|---|---|
| Chlorinated hydrocarbons (organochlorines) | lindane |
| Organophosphates | chlorpyrifos, coumaphos, diazinon, dichlorvos, dioxathion, ethion, famphur, fenthion, malathion, naled, phosmet, pirimiphos-methyl, stirofos, trichlorfon |
| Carbamates | carbaryl, methomyl |
| Pyrethroids | allethrin, cyfluthrin, cypermethrin, fenvalerate, flucythrinate, lambda-cyhalothrin, permethrin, pyrethrins, resmethrin, zeta-cypermethrin |
| Formamidines | amitraz |
| Insect juvenile-hormone analogs | methoprene |
| Substituted ureas | diflubenzuron |
| Avermectins and other macrocyclic lactones | doramectin, eprinomectin, ivermectin, moxidectin |
| Spinosyns | spinosad |
| Synergists | piperonyl butoxide (PBO) |
| Others | boric acid, cyromazine, diatomaceous earth |

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# 7

# Insect Pest Management for Commercial Vegetable Crops

- The insecticide Entrust received EPA labeling and approval for use in organic production by OMRI (Organic Materials Review Institute) in 2003. Entrust contains the active ingredient spinosad, a compound (or group of compounds) produced by soil actinomycetes. The insecticide SpinTor also contains spinosad but is not approved for organic production because other ingredients in the SpinTor formulation do not meet organic standards. Registered uses of spinosad (as Entrust or SpinTor) are listed in Table 1.
- Assail, a neonicotinoid insecticide containing the active ingredient acetamiprid, was labeled during 2003 for use on several vegetable crops, including cole crops (broccoli, cabbage, etc.), crucifer or brassica greens (collards, kale, etc.), other leafy greens (Swiss chard, spinach, rhubarb, etc.), melons, peppers, tomatoes, and eggplant. Target pests include aphids, whiteflies, and Colorado potato beetle.
- The miticide Acramite (bifenazate) is now registered for use on cucurbits, eggplant, peppers, and tomatoes for control of twospotted spider mite. Its mode of action differs from that of Agri-Mek (abamectin) and other miticides, so it represents a valuable addition for mite management and resistance management.
- Rimon (novaluron) is now registered for use in potatoes and sweet potatoes; pests on the label include Colorado potato beetle. The mode of action of novaluron differs from other potato insecticides, so it may be useful in resistance-management programs.
- Bifenthrin is the active ingredient in Capture 2E. It is also the active ingredient in Discipline 2EC, now available from Amvac. Like Capture 2E, Discipline 2EC is a restricted-use pesticide.
- The active ingredient in the insecticide Warrior is lambda-cyhalothrin. The new insecticide Proaxis contains gamma-cyhalothrin, a more active isomer of the same chemical formula. It is labeled for use on the same crops as Warrior—snap beans, broccoli, Brussels sprouts, cabbage, cauliflower, eggplant, garlic, lettuce, bulb onions, peas, peppers, sweet corn, and tomatoes—and against the same pests. The label calls for application of one-half the amount of active ingredient called for on the Warrior label. Like Warrior, Proaxis is a restricted-use pesticide.
- Surround (kaolin, a naturally occurring clay) is labeled for use on cucurbits, onions, tomatoes, eggplants, and peppers for the *suppression* of several pest insects. Target pests include the Colorado potato beetle, flea beetles, leafhoppers, tomato fruitworm (also called corn earworm), and cucumber beetles. Surround is applied at high rates and leaves a "particle film" on treated foliage and fruits. This physical film deters damage from several types of insect pests, but Surround is unlikely to provide complete control of most species. In combination with other insecticides, it may provide significant benefits for organic growers.
- For each pest of each crop, Table 1 lists a botanical or microbial insecticide if one is reasonably effective against the target pest. The use of microbial and bo-

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

tanical insecticides is allowed by most certification programs that cover organic production.

- The University of Illinois produces a newsletter covering timely issues in commercial fruit and vegetable production and pest management. The *Illinois Fruit and Vegetable News* is published weekly during the crop season and periodically in the off-season, for a total of 20 issues per year. For more information on subscriptions, contact Rick Weinzierl at (217)333-6651 or weinzier@uiuc.edu.

Insect control is a major concern for commercial vegetable producers. Processors, grocers, and most consumers do not purchase insect-damaged or insect-contaminated produce. At the same time, processors, distributors, and consumers are concerned about pesticide residues; they want to know that the health benefits provided by eating vegetables are not offset by any possible risks posed by pesticides that remain on fresh produce. To meet simultaneous demands for maximum pest control and minimum pesticide residues, careful selection and use of insecticides are essential steps in commercial vegetable production.

The guidelines in this chapter are not intended for use by home gardeners. Commercial producers should be trained and equipped to handle a variety of pesticides, including some that are highly toxic. Because few home gardeners are similarly trained or equipped, and because yield and cosmetic standards are not rigorous for the backyard garden, home gardeners are advised to choose among insecticides that are generally less hazardous to store, mix, and apply. A guide to insecticides for yard and garden use is presented in a separate publication. Call or write ACES/ITCS Marketing and Distribution, 1917 S. Wright St., Champaign, IL 61820; (217)333-2007 or (800)345-6087.

Most of the information contained here is presented in table format. Table 1 lists the registered insecticides that are most likely to control specific target pests in specific commodities in Illinois. Information on the safety and effectiveness of individual insecticides was evaluated to develop these lists; not all registered and legal uses are presented in Table 1.

Table 2 provides a more complete list of insecticides registered for use on vegetables; it also summarizes mandatory preharvest intervals (the time that must elapse between final application and harvest) for applications to specific crops. Check individual product labels for additional restrictions, such as the use of crop residues (tops, trimmings, stalks, and so forth) for livestock feed. Certain insecticides listed in Table 2 are not among the best choices for the control of Illinois vegetable pests, but they are registered and may be used legally. Consequently, the information in Table 2 may be useful where drift, overspray, or other contamination is a concern.

Pesticides may be identified by common chemical names (not capitalized) or by trade names (capitalized). Because one or more manufacturers may assign different trade names to products containing the same active ingredient, two or more commercial insecticides may be virtually identical. The tables in this chapter list insecticides by common chemical names, with trade names in parentheses.

Where insecticides must be used, several important steps help to ensure safety and effectiveness. Applicators must read and follow label instructions. Labels specify maximum application rates, maximum number of applications, and the preharvest interval. Labels also specify the crops on which an insecticide may be applied; application to crops or sites not specified on the label is illegal and can result in fines or imprisonment or both. To document the legal use of insecticides, producers should keep records of insecticide applications for every field. For restricted use pesticides, these records must include (1) the brand or product name and USEPA registration number for the pesticide applied; (2) the total amount of the product (formulated product, not active ingredient) applied; (3) the location of the application; (4) the size of the treated area; (5) the crop, commodity, or site treated; (6) the month, day, and year of application; and (7) the name and certification or license number of the applicator. Although these record-keeping rules cover only restricted use pesticides, we strongly urge applicators to keep complete records on all pesticide applications.

Pesticides classified for restricted use (identified in the tables by asterisks) may be purchased only by a licensed private or commercial pesticide applicator and applied only by or under the direct supervision of a licensed applicator. The Illinois Department of Agriculture (IDA) is responsible for testing and licensing pesticide applicators; contact an IDA or University of Illinois Extension office for information on training and examination programs. Farmers may apply general use pesticides (not restricted) according to label directions without obtaining a private applicator's license. Whenever any pesticide is used, applicators must take proper safety precautions to prevent excessive or unnecessary exposures that might endanger themselves, other workers, or family members. After pesticides are applied, reentry restrictions must be observed.

The list of insecticides registered for use on specific crops may change at any time during the year. Label changes are announced through newsletters and other media. Producers should also check with an Extension office for information updates.

*(Text continues on page 232.)*

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **ASPARAGUS** | | | |
| Asparagus beetle | Treat spears during the harvest season if infestations exceed 5 to 10 adults per 100 crowns or if eggs are present on more than 2% of the spears. Treat ferns postharvest if defoliation exceeds 10% or more than 50% of plants are infested. | | |
| | carbaryl (Sevin) | 1 to 2 lb | 1 day. |
| | chlorpyrifos (Lorsban) | 1 lb | 1 day. |
| | malathion | 1 lb | 1 day. |
| | *methomyl (Lannate) | 0.45 to 0.90 lb | 1 day. |
| | *permethrin (Ambush, Pounce) | 0.05 to 0.1 lb | 1 day. Do not exceed 0.4 lb a.i./acre/season. |
| | rotenone | Follow label directions. | 1 day. |
| | spinosad (Entrust, SpinTor) | 0.062 to 0.094 lb | Apply postharvest only to ferns. |
| Cutworms | Treat spears when infestations exceed 1 larva per 10 crowns. | | |
| | chlorpyrifos (Lorsban) | 1 lb | 1 day. |
| | *methomyl (Lannate) | 0.45 to 0.90 lb | 1 day. |
| | *permethrin (Ambush, Pounce) | 0.1 lb | 1 day. Do not exceed 0.4 lb a.i./acre/season. |
| Asparagus aphid | Rarely a serious pest in the Midwest. Treat ferns with chlorpyrifos, malathion, or rotenone as listed for asparagus beetle or with azadirachtin (Align or Neemix) according to product labels. | | |
| **BEANS (SNAP BEANS)** | | | |
| Seed maggots | Purchase seed that has been treated with Cruiser (thiamethoxam) or Lorsban (chlorpyrifos) or treat with Lorsban 50SL as listed below. Seed treated with Cruiser will control bean leaf beetle, aphids, and leafhoppers for 1 to 3 weeks after seedling emergence. This will not reduce introduction of plant viruses into fields by aphid vectors. | | |
| | chlorpyrifos (Lorsban 50SL) | 2 oz/100 lb seed | Seed treatment; apply as slurry. |
| Bean leaf beetle | Peak numbers of beetles occur in late May to early June, then again in August to September. Treat seedlings if defoliation is severe. After establishment, plants withstand moderate defoliation and suffer no loss in yield. Control even light infestations after pods form to prevent cosmetic damage from feeding scars. Planting seed treated with Cruiser (thiamethoxam) results in systemic uptake that reduces bean leaf beetle populations for 1 to 3 weeks after seedling emergence. | | |
| | acephate (Orthene) | 0.5 to 1.0 lb | 14 days. (0 days for lima beans.) Do not use treated vines for feed. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 3 days. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 1 lb | 3 days. |
| | dimethoate | 0.25 to 0.5 lb | 0 days. Do not use treated vines for feed. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 3 days. Do not use treated vines for feed. Not for lima beans for processing. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **BEANS (SNAP BEANS) (CONT.)** | | | |
| Bean leaf beetle (cont.) | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 7 days. Do not exceed 0.12 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | rotenone | 0.4 lb | 1 day. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.035 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Potato leafhopper | Treat if populations exceed 1 adult per sweep or 1 nymph per 10 leaves. For plants smaller than the 2-true-leaf stage, treat if counts exceed 1 adult per 2 sweeps. Planting seed treated with Cruiser (thiamethoxam) results in systemic uptake that reduces potato leafhopper populations for 1 to 3 weeks after seedling emergence. | | |
| | *bifenthrin (Capture, Discipline) | 0.025 to 0.10 lb | 3 days. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 1 lb | 3 days. |
| | dimethoate | 0.25 to 0.5 lb | 0 days. Do not use treated vines for feed. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 3 days. Do not use treated vines for feed. |
| | *esfenvalerate (Asana) | 0.03 lb | 3 days. Do not exceed 0.2 lb a.i./acre/season. Do not use treated vines for feed. |
| | imidacloprid (Admire) | See label for soil band and in-furrow application rates. | 21 days. |
| | imidacloprid (Provado) | 0.05 lb | 7 days. Do not exceed 3 foliar applications or a total of 0.5 lb a.i./acre/season for Admire and Provado combined. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 7 days. Do not exceed 0.12 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | malathion | 1 lb | 1 day. |
| | *methomyl (Lannate) | 0.45 lb | 3 days. 7-day PHI for feeding treated vines to livestock. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.035 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Mexican bean beetle | acephate (Orthene) | 0.5 to 1 lb | 14 days. (0 days for lima beans.) Do not use treated vines for feed. |
| | carbaryl (Sevin) | 1 lb | 3 days. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 7 days. Do not exceed 0.12 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | malathion | 0.5 to 1 lb | 1 day. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.035 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Aphids | Planting seed treated with Cruiser (thiamethoxam) results in systemic uptake that kills aphids for 1 to 3 weeks after seedling emergence. This does not, however, prevent aphids from transmitting viruses during their initial feeding probes before they are killed. | | |
| | acephate (Orthene) | 0.5 to 1 lb | 14 days. (0 days for lima beans.) Do not use treated vines for feed. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 3 days. Do not exceed 0.20 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **BEANS (SNAP BEANS) (CONT.)** | | | |
| Aphids (cont.) | dimethoate | 0.25 to 0.5 lb | 0 days. Do not use treated vines for feed. |
| | imidacloprid (Admire) | See label for soil band and in-furrow application rates. | 21 days. |
| | imidacloprid (Provado) | 0.05 lb | 7 days. Do not exceed 3 foliar applications or a total of 0.5 lb a.i./acre/season for Admire and Provado combined. |
| | malathion | 1 lb | 1 day. |
| | *methomyl (Lannate) | 0.45 lb | 3 days. 7-day PHI for feeding treated vines to livestock. |
| Corn earworm | Treat if pheromone-baited cone traps consistently capture earworm moths (more than 5 to 10 per night) and egg laying in beans is likely. Moths are most likely to deposit eggs in beans if surrounding cornfields are not silking. | | |
| | acephate (orthene) | 1 lb | 14 days. (0 days for lima beans.) Do not use treated vines for feed. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 3 days. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 1.5 lb | 3 days. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 3 days. Do not exceed 0.2 lb a.i./acre/season. Do not use treated vines for feed. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 7 days. Do not exceed 0.12 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.45 lb | 3 days. 7-day PHI for feeding treated vines to livestock. |
| | spinosad (Entrust, SpinTor) | 0.062 to 0.094 lb | 3 days. Do not apply more than 0.45 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.035 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| European corn borer | Operate one or more light traps beginning 1 to 2 weeks before bloom and until 1 week before harvest. If light traps capture more than 25 moths per night, begin insecticide applications when the first inch-long beans are present. Apply Lannate at 2- to 3-day intervals or Orthene at 5- to 7-day intervals. Larvae that hatch in the last 2 or 3 days before harvest will not mature enough to enter pods. | | |
| | acephate (Orthene) | 1 lb | 14 days. Do not use treated vines for feed. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 3 days. Do not exceed 0.20 lb a.i./acre/season. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 7 days. Do not exceed 0.12 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.45 lb | 3 days. 7-day PHI for feeding treated vines to livestock. Must be applied at 2- to 3-day intervals. |
| | spinosad (Entrust, SpinTor) | 0.047 to 0.094 lb | 3 days. Do not apply more than 0.45 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.035 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **BEANS (SNAP BEANS) (CONT.)** | | | |
| Spider mites | Mite outbreaks are rare in beans under sprinkler irrigation; outbreaks may occur late in the season during prolonged dry periods. | | |
| | *bifenthrin (Capture, Discipline) | 0.08 to 0.10 lb | 3 days. Do not exceed 0.20 lb a.i./acre/season. |
| | dicofol (Kelthane) | 0.5 to 1.5 lb | 21 days. Do not exceed 2 applications/season. |
| | dimethoate | 0.25 to 0.5 lb | 0 days. Do not use treated vines for feed. |
| Whiteflies | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/ 50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact whiteflies to be effective. |
| | Sprays of bifenthrin (Capture, Discipline), dimethoate, endosulfan (Thiodan), esfenvalerate (Asana), imidacloprid (Provado), or methomyl (Lannate) as listed for leafhopper or aphid control may also control whiteflies. Efficacy is likely to vary according to specific insecticide-resistance levels in separate whitefly populations. | | |
| **PEAS** | | | |
| Caterpillars, including loopers | In peas grown for processing, check for loopers and other larvae 10 days before harvest. Treat if counts exceed 1 larva per 25 sweeps during the period 10 to 21 days before harvest to prevent contamination. | | |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 3 days. Do not exceed 0.20 lb a.i./acre/season. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 3 days. Do not exceed 0.1 lb a.i./acre/season. Do not use treated vines for feed. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 7 days. Do not exceed 0.12 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.45 to 0.9 lb | 1 day. 5-day PHI for livestock forage; 14-day PHI for pea-vine hay. |
| | spinosad (Entrust, SpinTor) | 0.062 to 0.094 lb | 3 days (28 days for dry peas or dry beans). Do not apply more than 0.45 lb a.i./acre/season (or more than 0.19 lb a.i./acre/season on dry peas or dry beans). |
| | *zeta-cypermethrin (Fury, Mustang) | 0.035 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Aphids, including pea aphid | Treat if counts exceed 1 pea aphid per pod or 10 per sweep during the period 15 to 35 days before harvest. | | |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 3 days. Do not exceed 0.20 lb a.i./acre/season. |
| | dimethoate | 0.17 lb | 0 days. 21-day PHI if treated vines are to be used for livestock feed. Limit of 1 application per season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **PEAS (CONT.)** | | | |
| Aphids, including pea aphid (cont.) | *esfenvalerate (Asana) | 0.015 to 0.03 lb | 3 days. Do not exceed 0.1 lb a.i./acre/season. Do not use treated vines for feed. |
| | *methomyl (Lannate) | 0.45 to 0.90 lb | 1 day. 5-day PHI for livestock forage; 14-day PHI for pea-vine hay. |
| **BROCCOLI, BRUSSELS SPROUTS, CABBAGE, AND CAULIFLOWER** | | | |
| Cabbage maggot | Use in-furrow or broadcast applications of diazinon at or just before planting. Use drenches of diazinon or Lorsban during transplanting. Diazinon resistance has been observed in some areas. | | |
| | chlorpyrifos (Lorsban) | 1.6 to 2.4 fl oz 4EC in 50 gal. water/1,000 row ft of broccoli, Brussels sprouts, or cabbage<br>1.6 to 2.8 fl oz 4EC in 50 gal. water/1,000 row ft of cauliflower | 30 days. Apply to soil at base of transplants immediately after setting. |
| | diazinon | 0.25 to 0.5 pt AG500 or 0.25 to 0.5 lb 50WP in 50 gal. water. Use 0.5 to 1 cup/plant. | Apply to soil at base of transplants immediately after setting. |
| | diazinon | 3 lb | Broadcast and incorporate before planting. |

**Scouting for aphids and foliage-feeding caterpillars:** Check 5 to 10 randomly selected plants in each of 5 to 10 or more areas per field. For each plant, record the presence of any live larvae of diamondback moth, cabbage looper, or imported cabbage worm; classify each plant as infested or uninfested (note which pest species); also record whether or not aphids are present for each plant. Sample fields once or twice per week. Treat if the percentage of plants infested by caterpillars exceeds the following levels for specific stages of development.

| **Broccoli and cauliflower:** | | **Cabbage:** | |
|---|---|---|---|
| Seedbed | 10% | Seedbed | 10% |
| Transplant to first flower or first curd | 50% | Transplant to cupping | 30% |
| | | Cupping to early head | 20% |
| Flower bud or curd to harvest | 10% | Mature head | 10% |

Other scouting guidelines have also been proposed; contact the University of Illinois Department of Crop Sciences at (217)333-6651 for more information. Aphid control is recommended for cabbage whenever aphid colonies are detected. Control often can be delayed in broccoli and cauliflower until "cleanup" is necessary just before heading to prevent contamination at harvest. Aphid control in seedbeds is especially important for all these crops.

| | | | |
|---|---|---|---|
| Aphids | acephate (Orthene) | 0.5 to 1 lb | 14 days. Brussels sprouts and cauliflower only. |
| | acetamiprid (Assail) | 0.035 to 0.054 lb | 7 days. Do not exceed 0.375 lb a.i./acre/season. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 7 days. Do not exceed 0.5 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **BROCCOLI, BRUSSELS SPROUTS, CABBAGE, AND CAULIFLOWER (CONT.)** | | | |
| Aphids (cont.) | diazinon | 0.5 lb | 7 days broccoli, Brussels sprouts, and cauliflower; 21 days cabbage. Do not exceed 5 applications per season. |
| | dimethoate | 0.25 to 0.5 lb | 7 days for broccoli and cauliflower; 3 days for cabbage. Do not use on Brussels sprouts. |
| | endosulfan (Thiodan) | 1 lb | 7 days for broccoli and cabbage; 14 days for Brussels sprouts and cauliflower. Do not exceed 2 applications per season. |
| | imidacloprid (Admire) | Up to 24 fl oz formulated product per acre. See label for application rates and methods. | 21 days. |
| | imidacloprid (Provado) | 0.05 lb | 7 days. Allow at least 7 days between applications. Do not exceed 0.24 lb a.i./acre/season. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact aphids to be effective. |
| | naled (Dibrom) | 1 lb | 1 day. |
| | pymetrozine (Fulfill) | 0.09 lb | 7 days. |
| Cabbage looper; diamondback moth; imported cabbage worm | Thorough coverage is important; some labels recommend wetting agents. In some areas, diamondback moth has become resistant to endosulfan, methomyl, permethrin, and other compounds; resistance levels vary within the state and locally. Use *Bt* products, especially before heading, to preserve natural enemies of caterpillars and aphids and to minimize problems from diamondback moth resistance to other insecticides. | | |
| | *azinphosmethyl (Guthion) | 0.5 to 0.75 lb | 15 days for broccoli and cauliflower; 7 days for Brussels sprouts; 21 days for cabbage. Do not exceed 3 applications per season. WP formulations are not restricted use. |
| | *Bacillus thuringiensis kurstaki* or *aizawai (Bt)* (Agree, Biobit, Cutlass, Dipel, Javelin, MVP, XenTari, and others) | Follow label directions. | 0 days. Kills only the caterpillar stage; must be eaten by larvae to be effective. *Bt* products are less effective against large (older) cabbage loopers than against younger loopers and other caterpillars. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 7 days. Do not exceed 0.50 lb a.i./acre/season. |
| | *cypermethrin (Ammo) | 0.05 to 0.1 lb | 1 day. Do not exceed 0.6 lb a.i./acre/season. |
| | *emamectin benzoate (Proclaim) | 0.008 to 0.015 lb | 7 days. Do not exceed 0.09 lb a.i./acre/season. Wait at least 7 days between applications. No more than 2 consecutive applications without rotation to another insecticide. |
| | endosulfan (Thiodan) | 1 lb | 7 days for broccoli and cabbage; 14 days for Brussels sprouts and cauliflower. Do not exceed 2 applications per season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **BROCCOLI, BRUSSELS SPROUTS, CABBAGE, AND CAULIFLOWER (CONT.)** | | | |
| Cabbage looper, diamondback moth, imported cabbage worm (cont.) | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 3 days. Do not use on Brussels sprouts. Do not exceed 0.4 lb a.i./acre/season. Not labeled for diamondback moth. |
| | fenpropathrin (Danitol) | 0.2 to 0.3 lb | 7 days. Do not exceed 0.8 lb a.i./acre/season. For diamondback moth control in Brussels sprouts and cauliflower, the label recommends combination with acephate (Orthene). Orthene is *not* labeled for use on cabbage or broccoli. |
| | indoxacarb (Avaunt) | 0.045 to 0.065 lb | 3 days for broccoli, cabbage, and cauliflower. Use 0.65 lb a.i. rate against diamondback moth. Add a wetting agent to improve coverage. Do not exceed 0.26 lb a.i./acre/season. |
| | *lambda-cyhalothrin (Warrior) | 0.015 to 0.03 lb | 1 day for broccoli and cabbage. Do not exceed 0.24 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.23 to 0.9 lb | 3 days for broccoli, Brussels sprouts, cauliflower; 1 day for cabbage. Also aids in aphid control. |
| | methoxyfenozide (Intrepid) | 0.12 to 0.16 lb | 1 day. Do not exceed 1 lb a.i./acre/season. Increase rate to 0.25 lb a.i./acre for suppression of diamondback moth. |
| | *permethrin (Ambush, Pounce) | 0.05 to 0.1 lb for broccoli, Brussels sprouts, and cauliflower | 1 day. Do not exceed 0.8 lb a.i./acre/season on broccoli, Brussels sprouts, and cauliflower. |
| | | 0.05 to 0.2 lb for cabbage | Do not exceed 1 lb a.i./acre/season on cabbage. |
| | spinosad (Entrust, SpinTor) | 0.023 to 0.094 lb | 1 day. Do not exceed 0.45 lb/acre/crop. See label for further restrictions for resistance management. |
| | tebufenozide (Confirm) | 0.09 to 0.12 lb | 7 days. Do not exceed 0.84 lb a.i./acre/season. *Not* labeled against diamondback moth. |
| | thiodicarb (Larvin) | 0.4 to 1 lb | 7 days. Do not use on Brussels sprouts. Do not exceed 6 lb a.i./acre/season. |
| | *tralomethrin (Scout X-tra) | 0.016 to 0.024 lb | 5 days. Broccoli only; do not apply to cabbage, Brussels sprouts, or cauliflower. Do not exceed 0.2 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.03 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Cutworms | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 7 days. Do not exceed 0.50 lb a.i./acre/season. |
| | chlorpyrifos (Lorsban) | 1 lb | 21 days. Do not exceed 6 applications per season. Use 50W formulation. Do not mix with other pesticides or apply in extreme heat or drought. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 3 days. Apply as basal spray after planting if cutworm damage occurs. Do not use on Brussels sprouts. Do not exceed 0.4 lb a.i./acre/season. |
| | *lambda-cyhalothrin (Warrior) | 0.015 to 0.025 lb | 1 day for broccoli and cabbage. Do not exceed 0.24 lb a.i./acre/season. Proaxis (gamma-cyhalo thrin) also is registered. See the label for rates and restrictions.) |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **BROCCOLI, BRUSSELS SPROUTS, CABBAGE, AND CAULIFLOWER (CONT.)** | | | |
| Flea beetles | Critical stages for control: seedlings and transplants. Except for *Bacillus thuringiensis*, methoxyfenozide (Intrepid), and tebufenozide (Confirm), insecticides used to control cabbage looper and other caterpillars also control flea beetles. In addition to the products listed for control of loopers and other caterpillars, the following insecticides are effective against flea beetles. | | |
| | carbaryl (Sevin) | 0.5 to 1 lb | 3 days. |
| | cryolite (ProKil) | 10 to 16 lb | 7 days. Do not exceed 96 lb a.i./acre/season. |
| | imidacloprid (Provado) | 0.05 lb | 7 days. Allow at least 7 days between applications. Do not exceed 0.24 lb a.i./acre/season. |
| | rotenone | 0.4 lb | 1 day. |
| Onion thrips | Thrips control may be necessary in cabbage as heads begin to form. Capture, Cygon, or Monitor as used for aphid control also gives some control of thrips. | | |
| | *cypermethrin (Ammo) | 0.075 to 0.1 lb | 1 day. Do not exceed 0.6 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.04 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| **RADISHES AND TURNIPS (ROOTS)** | | | |
| Cabbage maggot | Use in-furrow applications at planting for radishes and turnips. Also apply a diazinon drench to turnips 30 days after planting. | | |
| | chlorpyrifos (Lorsban) | 1 fl oz 4E or 33 oz 15G/1,000 row ft | Apply only at planting. Use 4E as a drench (minimum of 40 gallons water/acre); place 15G in seed furrow. |
| | diazinon | 0.5 lb | 14 days. For turnips, apply as a drench over the row 30 days after planting. Also controls flea beetles. |
| | diazinon | 2.5 oz 14G/1,000 row ft | Apply only at planting; place in seed furrow. |
| Aphids and flea beetles | carbaryl (Sevin) | 1 lb | 7 days. Does not control aphids. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days for radishes. Allow at least 7 days between applications. Do not exceed 5 applications per season. Not for aphid control. Do not apply to turnips. |
| | diazinon | 0.5 lb | 14 days. |
| | dimethoate | 0.25 lb | 14 days. Turnips only. May not control flea beetles. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact aphids to be effective. |
| | malathion | 1 lb | 7 days. Not labeled against flea beetles. |
| Cutworms | carbaryl (Sevin) | 1 to 2 lb | 7 days. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days for radishes. Allow at least 7 days between applications. Do not exceed 5 applications per season. Do not apply to turnips. |
| | diazinon | 2 to 4 lb | 14 days. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **COLLARDS, KALE, MUSTARD GREENS, AND TURNIP GREENS** | | | |
| Aphids | Treat seedlings if aphid densities exceed 1 per plant; treat established plants if aphid densities exceed 4 to 10 per plant. | | |
| | acetamiprid (Assail) | 0.035 to 0.054 lb | 7 days. Do not exceed 0.375 lb a.i./acre/season. |
| | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | diazinon | 0.5 lb | 10 days for collards, kale, and mustard greens. 14 days for turnip. Do not exceed 5 applications per season. |
| | dimethoate | 0.25 lb | 14 days. |
| | endosulfan (Thiodan) | 0.75 lb | 21 days. Use 2EC formulation. Apply only once a season. Do not use on turnips grown for roots. |
| | imidacloprid (Admire) | See label for rates per linear foot of row based on row spacings. | 21 days. Apply to soil as a band or in-furrow treatment at bedding or seeding, post-seeding drench, as a sidedress, or in trickle irrigation. Do not use on turnips grown for roots. |
| | imidacloprid (Provado) | 0.05 lb | 7 days for collards, kale, and mustard greens. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. Do not apply to turnips grown for roots. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/ 50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact aphids to be effective. |
| | naled (Dibrom) | 1 lb | 1 day for collards and kale. Do not apply to mustard greens or turnip greens. |
| | pymetrozine (Fulfill) | 0.09 lb | 7 days. |
| Cutworms | carbaryl (Sevin) | 2 lb | 14 days. |
| | chlorpyrifos (Lorsban) | 1 lb | 21 days. Collards and kale only. Use 50W formulation. Do not exceed 6 applications per season. Do not mix with other pesticides or apply in extreme heat or drought. |
| Leafhoppers | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | carbaryl (Sevin) | 0.5 to 1 lb | 14 days. |
| | dimethoate | 0.25 lb | 14 days. |
| | malathion | 1 lb | 7 days. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **COLLARDS, KALE, MUSTARD GREENS, AND TURNIP GREENS (CONT.)** | | | |
| Cabbage looper; diamondback moth; imported cabbage worm | For most commercial markets, treat if 5% of plants are infested with larvae of any of these species. Higher infestation levels may be tolerated, depending on market demands. Thorough coverage is necessary; some labels recommend wetting agents. In some areas, diamondback moth has become resistant to endosulfan, methomyl, permethrin, and other compounds; resistance levels vary within the state and locally. Use *Bt* products, especially when plants are small, to preserve natural enemies of caterpillars and aphids and to minimize problems from diamondback moth resistance to other insecticides. | | |
| | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | *Bacillus thuringiensis kurstaki* or *aizawai (Bt)* (Agree, Biobit, Cutlass, DiPel, Javelin, MVP, XenTari, and others) | Follow label directions. | 0 days. Kills only the caterpillar stage; must be eaten by larvae to be effective. *Bt* products are less effective against large (older) cabbage loopers than against younger loopers and other caterpillars. |
| | *cypermethrin (Ammo) | 0.05 to 0.1 lb | 1 day. Turnip greens are not listed on the product label. |
| | diazinon | 0.5 lb | 10 days for collards, kale, and mustard greens. 14 days for turnip greens (and roots). Do not exceed 5 applications/season. |
| | endosulfan (Thiodan) | 0.75 lb | 21 days. Use 2EC formulation. Apply only once per season. Do not use on turnips grown for roots. |
| | *methomyl (Lannate) | 0.45 to 0.9 lb | 10 days. Also aids in aphid control. |
| | methoxyfenozide (Intrepid) | 0.12 to 0.16 lb | 1 day. Do not exceed 1 lb a.i./acre/season. Increase rate to 0.25 lb a.i./acre for suppression of diamondback moth. |
| | naled (Dibrom) | 1 to 2 lb | 1 day. Do not apply to mustard greens or turnip greens. |
| | *permethrin (Ambush, Pounce) | 0.05 to 0.1 lb | 1 day for collards and turnip greens. Do not apply to kale or mustard greens. Do not exceed 8 applications to collards or 4 applications to turnip greens per season. |
| | spinosad (Entrust, SpinTor) | 0.023 to 0.125 lb | 1 day. Do not exceed 0.45 lb/acre/crop. Label does not include turnips grown for roots. See label for further restrictions for resistance management. |
| | tebufenozide (Confirm) | 0.09 to 0.12 lb | 7 days. Do not exceed 0.84 lb a.i./acre/season. *Not* labeled against diamondback moth. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.028 to 0.05 lb | 1 day. Turnip greens are not listed on the label. |
| Flea beetle | Except for *Bacillus thuringiensis,* methoxyfenozide (Intrepid), and tebufenozide (Confirm), insecticides used to control cabbage looper and other caterpillars also kill flea beetles. | | |
| | carbaryl (Sevin) | 1 lb | 14 days. |
| | imidacloprid (Provado) | 0.05 lb | 7 days. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. Do not use on turnips grown for tops or roots. |
| | rotenone | See product label. | 1 day for collards. Do not apply to kale, mustard greens, or turnip greens. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **HORSERADISH** | | | |
| Diamondback moth | Populations build in late summer but rarely warrant control. Horseradish tolerates substantial feeding (removal of greater than 30% of leaf tissue) by diamondback moth without reduction in yield (root growth). If treatment is warranted, thorough coverage is necessary; some labels recommend wetting agents. In some areas, diamondback moth has become resistant to endosulfan, methomyl, permethrin, and other compounds; resistance levels vary within the state and locally. Use *Bt* products to preserve natural enemies of caterpillars and aphids and to minimize problems from diamondback moth resistance to other insecticides. | | |
| | *Bacillus thuringiensis kurstaki* or *aizawai (Bt)* (Agree, Biobit, Cutlass, DiPel, Javelin, MVP, XenTari, and others) | Follow label directions. | 0 days. Kills only the caterpillar stage; must be eaten by larvae to be effective. |
| | *permethrin (Ambush, Pounce) | 0.1 lb | 22 days. Do not exceed 3 foliar applications per season. |
| Beet leafhopper, flea beetle | Beet leafhopper transmits the brittleroot pathogen. Treat if more than a few beet leafhoppers are collected in the area before mid-August. | | |
| | imidacloprid (Admire) | 10 to 24 fl oz formulated product per acre. See label for application rates and methods. | 21 days. |
| | imidacloprid (Provado) | 0.04 lb | 7 days. Do not exceed 3 applications/season. |
| | *methomyl (Lannate) | 0.45 lb | 65 days. |
| | *permethrin (Ambush, Pounce) | 0.1 lb | 22 days. Do not exceed 3 foliar applications per season. |
| Imported crucifer weevil | *permethrin (Ambush, Pounce) | 0.1% a.i. solution | At planting. Treat if sets are infested or fields have a history of weevil damage. Soak sets 30 minutes and air dry before planting. |
| | *permethrin (Ambush, Pounce) | 0.2 lb | 22 days. Examine crowns in early August. Apply foliar spray if adult weevil populations exceed 1 to 3 per 10 plants, or use weevil history to determine potential for damage. Do not exceed 3 foliar applications per season. |
| **LEAF LETTUCE, SPINACH, AND SWISS CHARD** | | | |
| Aphids and leafminers | Treat seedlings if aphid densities exceed 1 per plant; treat established plants if aphid densities exceed 4 to 10 per plant. Treat seedlings for leafminer control if eggs or mines are present on 50% of the plants; as plants near harvest, treat to limit mines to no more than 5% of the leaves. | | |
| | acetamiprid (Assail) | 0.035 to 0.054 lb | 7 days. Do not exceed 0.375 lb a.i./acre/season. |
| | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | cyromazine (Trigard) | 2 oz | 7 days. Do not exceed 5 applications/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **LEAF LETTUCE, SPINACH, AND SWISS CHARD (CONT.)** | | | |
| Aphids and leafminers (cont.) | diazinon | 0.25 to 0.5 lb | 14 days. |
| | dimethoate | 0.25 lb | 14 days. |
| | endosulfan (Thiodan) | 0.75 to 1 lb | 14 days for leaf lettuce; 21 days for spinach. Do not apply to Swiss chard. Do not exceed 6 lb a.i./acre/season on lettuce or 1 application per season on spinach. |
| | imidacloprid (Admire) | See labels for rates per linear row ft based on row spacings. | 21 days. Apply to soil as a band or in-furrow treatment at bedding or seeding, as a post-seeding drench, as a sidedress, or in trickle irrigation. Do not use on Swiss chard. |
| | imidacloprid (Provado) | 0.05 lb | 7 days for leaf lettuce. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. Do not use on Swiss chard. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/ 50 gal. water (See comments.) | 0 days. For aphid control. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact aphids to be effective. |
| | pymetrozine (Fulfill) | 0.09 lb | 7 days. |
| | spinosad (SpinTor, Entrust) | 0.094 to 0.156 lb | 1 day. For leafminer control (not aphids). Do not exceed 0.45 lb/acre/crop. See label for further resistance-management restrictions. |
| Leafhoppers | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | *bifenthrin (Capture, Discipline) | 0.03 to 0.1 lb | 40 days on spinach only. Do not exceed 0.4 lb a.i./acre/season. Do not apply to leaf lettuce. |
| | carbaryl (Sevin) | 0.5 to 1 lb | 14 days. |
| | dimethoate | 0.25 lb | 14 days. |
| | imidacloprid (Admire) | 10 to 24 fl oz formulated product/ acre. See label for application rates and methods. | 21 days. |
| | imidacloprid (Provado) | 0.04 lb | 7 days. Do not exceed 3 applications per season. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 1 day on lettuce. Do not exceed 0.3 lb a.i./acre/ season. Do not apply to spinach. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | malathion | 1 lb | 14 days for leaf lettuce; 7 days for spinach and Swiss chard. |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 1 day. Do not exceed 2.0 lb a.i./acre/season. Do not feed or graze treated plants. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **LEAF LETTUCE, SPINACH, AND SWISS CHARD (CONT.)** | | | |
| Caterpillars, including loopers | See comments under "Broccoli. . ." on page 204 regarding diamondback moth resistance to endosulfan, methomyl, and permethrin. | | |
| | *Bacillus thuringiensis kurstaki* or *aizawai (Bt)* (Agree, Biobit, Cutlass, DiPel, Javelin, MVP, Xen-Tari, and others) | Follow label directions. | 0 days. Kills only the caterpillar stage; must be eaten by larvae to be effective. |
| | indoxacarb (Avaunt) | 0.045 to 0.065 lb | 3 days lettuce. Not labeled for use on spinach or Swiss chard. Do not exceed 0.26 lb a.i./acre/season. |
| | *lambda-cyhalothrin (Warrior) | 0.015 to 0.03 lb | 1 day on lettuce. Do not exceed 0.3 lb a.i./acre/season. Do not apply to spinach. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.45 to 0.9 lb | 7 days for spinach; 10 days for lettuce and Swiss chard. Also aids in aphid control. |
| | methoxyfenozide (Intrepid) | 0.12 to 0.16 lb | 1 day. Do not exceed 1 lb a.i./acre/season. Increase rate to 0.25 lb a.i./acre for suppression of diamondback moth. |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 1 day. Do not exceed 2.0 lb a.i./acre/season. Do not feed or graze treated plants. |
| | spinosad (Entrust, SpinTor) | 0.062 to 0.125 lb | 1 day. Do not exceed 0.45 lb/acre/crop. See label for further resistance-management restrictions. |
| | tebufenozide (Confirm) | 0.09 to 0.12 lb | 7 days. Do not exceed 0.84 lb a.i./acre/season. |
| | thiodicarb (Larvin) | 0.4 to 0.75 lb | 14 days. Do not exceed 1.5 lb a.i./acre/season. |
| Flea beetles | Except for *Bacillus thuringiensis*, methoxyfenozide (Intrepid), and tebufenozide (Confirm), insecticides listed for control of caterpillars, including loopers, also kill flea beetles. In addition to the products listed for control of caterpillars, the following insecticides are effective against flea beetles. | | |
| | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | carbaryl (Sevin) | 1 lb | 14 days. |
| | rotenone | See product label. | 1 day for lettuce and spinach. Do not apply to Swiss chard. |
| **CARROTS** | | | |
| Cutworms | *cyfluthrin (Baythroid) | 0.025 lb | 0 days. Allow at least 7 days between applications. Do not exceed 5 applications per season. |
| | diazinon | 2 to 4 lb | Broadcast and incorporate just before planting in fields that have a history of frequent cutworm damage. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 7 days. Do not exceed 0.5 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **CARROTS (CONT.)** | | | |
| Aster leafhopper | Control aster leafhoppers only to reduce aster yellows, the disease that they transmit. Contact the Department of Crop Sciences, University of Illinois, (217)333-6651, for information on leafhopper infectivity and varietal susceptibility to aster yellows and guidelines on treatment thresholds. In the absence of specific information on varietal susceptibility and leafhopper infectivity, use a threshold of 20 aster leafhoppers per 100 sweeps. | | |
| | carbaryl (Sevin) | 1 to 1.5 lb | 7 days. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days. Allow at least 7 days between applications. Do not exceed 5 applications per season. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 7 days. Do not exceed 0.5 lb a.i./acre/season. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 7 days. 1 application/season. Do not use treated tops for feed. |
| | imidacloprid (Admire) | 10 to 24 fl oz formulated product/acre. See label for application rates and methods. | 21 days. 1 application/season. |
| | imidacloprid (Provado) | 0.04 lb | 7 days. Do not exceed 3 applications/season. |
| | *methomyl (Lannate) | 0.45 to 0.9 lb | 1 day. |
| Aphids | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 7 days. 1 application/season. Do not use treated tops for feed. |
| | imidacloprid (Admire) | 10 to 24 fl oz formulated product/acre. See label for application rates and methods. | 21 days. 1 application/season. |
| | imidacloprid (Provado) | 0.04 lb | 7 days. Do not exceed 3 applications/season. |
| | diazinon | 0.5 lb | 14 days. |
| | malathion | 1.25 lb | 7 days. |
| Carrot weevil adults | *cyfluthrin (Baythroid) | 0.044 lb | 0 days. Allow at least 7 days between applications. Do not exceed 5 applications per season. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 7 days. Do not exceed 0.5 lb a.i./acre/season. |
| **CUCUMBERS, MELONS, PUMPKINS, AND SQUASH** | | | |
| To reduce bee kill in vine crops, apply insecticides only late in the day after blossoms have closed. | | | |
| Seed corn maggot | chlorpyrifos (Lorsban 50SL) | 2 oz/100 lb seed | Seed treatment. Apply as slurry. |
| Striped and spotted cucumber beetles | Control striped and spotted cucumber beetles to prevent bacterial wilt in cucumbers and muskmelon. In these crops, treat if beetle infestations exceed 0.1 to 1 per plant. In squash and pumpkins, treat if infestations exceed 5 beetles per plant. | | |
| | *bifenthrin (Capture, Discipline) | 0.04 to 0.10 lb | 3 days. Do not exceed 0.30 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **CUCUMBERS, MELONS, PUMPKINS, AND SQUASH (CONT.)** | | | |
| Striped and spotted cucumber beetles (cont.) | carbaryl (Sevin) | 1 lb | 3 days. Sevin XLR is the formulation of carbaryl that is least toxic to honeybees. |
| | carbaryl plus feeding attractants (Adios, SLAM) | 0.065 lb carbaryl | 3 days. Low toxicity to honeybees. |
| | *carbofuran (Furadan) | Use 2.4 oz Furadan 4F/1,000 row ft | Band-apply to soil at planting. |
| | fenpropathrin (Danitol) | 0.2 to 0.3 lb | 7 days. |
| | imidacloprid (Admire) | 0.25 to 0.375 lb | 21 days. Apply to soil at planting as a band or an in-furrow spray, as a post-seeding drench, as a sidedress after plants are established, or through irrigation. Do not exceed 0.375 lb a.i./acre/season. Provado, another insecticide that contains imidacloprid, is *not* labeled for use on cucurbits. |
| | kaolin (Surround) | 6.25 to 25 lb | 0 days. Apply at 7- to 14-day intervals beginning before infestations occur. Use additional insecticides to supplement control. (This product's primary use is in certified organic production.) |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 0 days. Do not exceed 1.6 lb a.i./acre/season. |
| | rotenone | See product label. | 1 day. |
| Aphids | *bifenthrin (Capture, Discipline) | 0.04 to 0.10 lb | 3 days. Do not exceed 0.30 lb a.i./acre/season. |
| | diazinon | 0.5 lb | 7 days for cucumbers and summer squash; 3 days for melons and winter squash. Do not apply to pumpkins. |
| | dimethoate | 0.25 lb | 3 days, melons only. Do not apply to cucumbers, pumpkins, or squash. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 0 days. Do not exceed 3 lb a.i./acre/year. Also controls cucumber beetles; aids in controlling squash bug and squash vine borer. |
| | imidacloprid (Admire) | 0.25 to 0.375 lb | 21 days. Apply to soil at planting as a band or an in-furrow spray, as a post-seeding drench, as a sidedress after plants are established, or through irrigation. Do not exceed 0.375 lb a.i./acre/season. Provado, another insecticide that contains imidacloprid, is *not* labeled for use on cucurbits. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact aphids to be effective. |
| | malathion | 1 lb | 1 day for cucumbers, melons, and squash; 3 days for pumpkins. |
| | pymetrozine (Fulfill) | 0.09 lb | 0 days. |
| | thiamethoxam (Actara) | 0.03 to 0.06 lb | 0 days. Do not exceed 0.125 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **CUCUMBERS, MELONS, PUMPKINS, AND SQUASH (CONT.)** | | | |
| Squash bug | Treat when first eggs begin to hatch (around June 15 to July 15) if infestations exceed 1 to 1.5 egg masses per plant. Treat when squash bug nymphs are young because registered insecticides are not very effective against older nymphs or adults. | | |
| | *bifenthrin (Capture, Discipline) | 0.04 to 0.10 lb | 3 days. Do not exceed 0.30 lb a.i./acre/season. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 3 days. Do not exceed 0.25 lb a.i./acre/season. |
| | *permethrin (Ambush, Pounce) | 0.2 lb | 0 days. Do not exceed 1.6 lb a.i./acre/season. |
| Leafhoppers | *bifenthrin (Capture, Discipline) | 0.04 to 0.10 lb | 3 days. Do not exceed 0.30 lb a.i./acre/season. |
| | dimethoate | 0.25 lb | 3 days, melons only. Do not apply to cucumbers, pumpkins, or squash. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 3 days. Do not exceed 0.25 lb a.i./acre/season. |
| | *permethrin (Ambush, Pounce) | 0.2 lb | 0 days. Do not exceed 1.6 lb a.i./acre/season. |
| Squash vine borer | When vines begin to run, scout twice weekly for red and black clear-winged moths and for entrance holes and frass. Treat as soon as early damage occurs and again 5 to 7 days later. Then continue scouting; treat as soon as new damage is noted. | | |
| | *bifenthrin (Capture, Discipline) | 0.04 to 0.10 lb | 3 days. Do not exceed 0.30 lb a.i./acre/season. |
| | carbaryl (Sevin) | 1 lb | 3 days. Use Sevin XLR to minimize bee kill. |
| | endosulfan (Thiodan) | 0.5 to 1.5 lb | 0 days. Do not exceed 3 lb a.i./acre/season. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 3 days. Do not exceed 0.25 lb a.i./acre/season. |
| | methoxychlor | 0.5 to 1 lb | 7 days. 1 day if less than 0.875 lb a.i./acre. |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 1 day. Do not exceed 1.6 lb a.i./acre/season. |
| | rotenone | See product label. | 1 day. |
| Pickleworm | Begin weekly sprays in mid-August if damage begins to occur. Not a common problem. | | |
| | *bifenthrin (Capture, Discipline) | 0.04 to 0.10 lb | 3 days. Do not exceed 0.30 lb a.i./acre/season. |
| | carbaryl (Sevin) | 1 lb | 3 days. Use Sevin XLR to minimize bee kill. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 0 days. Do not exceed 3 lb a.i./acre/season. Also controls cucumber beetles; aids in controlling squash bug and squash vine borer. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 3 days. Do not exceed 0.25 lb a.i./acre/season. |
| | spinosad (Entrust, SpinTor) | 0.062 to 0.125 lb | 1 day for cucumbers; 3 days for melons, squash, and pumpkins. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **CUCUMBERS, MELONS, PUMPKINS, AND SQUASH (CONT.)** | | | |
| Mites | *abamectin (Agri-Mek) | 0.01 to 0.02 lb | 7 days. Do not exceed 0.056 lb a.i./acre/season. |
| | bifenazate (Acramite) | 0.4 to 0.5 lb | 3 days. One application per season. |
| | *bifenthrin (Capture, Discipline) | 0.08 to 0.10 lb | 3 days. Do not exceed 0.30 lb a.i./acre/season. |
| | dicofol (Kelthane) | 0.35 to 0.6 lb | 2 days. Apply in 40 to 100 gal. water/acre. |
| | dimethoate | 0.25 lb | 3 days, melons only. Do not apply to cucumbers, pumpkins, or squash. |
| | fenpropathrin (Danitol) | 0.2 lb | 7 days all melons. Do not apply to cucumbers, pumpkins, or squash. Do not exceed 0.8 lb a.i./acre/season. |
| Cutworms | Treat young plants if infestations exceed 1 to 2 larvae per 100 plants. | | |
| | *bifenthrin (Capture, Discipline) | 0.04 to 0.10 lb | 3 days. Do not exceed 0.30 lb a.i./acre/season. |
| | *esfenvalerate (Asana) | 0.05 lb | 3 days. Do not exceed 0.25 lb a.i./acre/season. |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 0 days. Do not exceed 1.6 lb a.i./acre/season. |
| Whiteflies | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | imidacloprid (Admire) | 0.25 to 0.375 lb | 21 days. Apply to soil at planting as a band or an in-furrow spray, as a post-seeding drench, as a sidedress after plants are established, or through irrigation. Do not exceed 0.375 lb a.i./acre/season. Provado, another insecticide that contains imidacloprid, is *not* labeled for use on cucurbits. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/ 50 gal. water (See comments.) | 0 days. Use enough spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact whiteflies to be effective. |
| | Sprays of bifenthrin (Capture, Discipline), dimethoate (for melons only), endosulfan (Thiodan), esfenvalerate (Asana), fenpropathrin (Danitol), or thiamethoxam (Actara) as listed for leafhopper or aphid control also may control whiteflies. Efficacy is likely to vary according to specific insecticide-resistance levels in separate whitefly populations. | | |
| **ONIONS** | | | |
| Onion maggot | Practice crop rotation to reduce onion maggot attack. Use soil insecticides at planting as furrow or broadcast applications. Populations in some areas may be resistant to diazinon. Foliar sprays for adult suppression are not effective. | | |
| | chlorpyrifos (Lorsban) | 1 lb | In-furrow at planting (granular or EC formulations). |
| | diazinon | 1 lb | Preplant broadcast. Incorporate 1 to 2 in. by disking. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **ONIONS (CONT.)** | | | |
| Thrips | Check for thrips as bulbs begin to form. Thresholds vary from 10 to 25 per plant for susceptible varieties to as many as 45 per plant for more tolerant varieties. Onion varieties that are more susceptible to thrips injury include Brown Beauty 20, Colorado 6, Early Red Stockton, Mambo, Red Baron, Redman, Sweet Perfection, Tango, Valdez, and White Delight. Moderately tolerant varieties include El Charro, Snow White, Vega, X 201, and Zapotec. A more tolerant variety is White Keeper. Where insecticides are needed, treat during early bulb stage. Infestations are greatest in hot, dry weather. Direct ground-applied sprays to the center of plants. Wetting agents are recommended. | | |
| | *azinphosmethyl (Guthion) | 0.5 lb | 28 days for dry onions; 14 days for green onions. Do not exceed 3 applications per season. 25W and 2S formulations are not restricted use. Some thrips populations are resistant. |
| | *cypermethrin (Ammo) | 0.08 to 0.1 lb | 7 days. Do not exceed 0.5 lb a.i./acre/season. |
| | diazinon | 0.5 lb | 14 days. |
| | kaolin (Surround) | 6.25 to 25 lb | 0 days. Apply at 7- to 14-day intervals beginning before infestations occur. Use additional insecticides to supplement control. (This product's primary use is in certified organic production.) |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 14 days. Do not exceed 0.24 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is regis tered. See the label for rates and restrictions. |
| | malathion | 1 lb | 3 days. |
| | *methomyl (Lannate) | 0.45 lb | 7 days. |
| | *methyl parathion (Penncap-M) | 0.5 lb | 15 days. |
| | *permethrin (Ambush, Pounce) | 0.15 to 0.3 lb | 1 day. Dry bulb onions only. Do not exceed 2.4 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.04 to 0.05 lb | 7 days. Bulb onions only. Do not exceed 0.25 lb a.i./acre/season. |
| **PEPPERS** | | | |
| Aphids | Use the insecticides below to control aphids where colonies are building. Insecticides are not effective for preventing or controlling aphid-borne viral diseases in peppers. | | |
| | acetamiprid (Assail) | 0.035 to 0.054 lb | 7 days. Do not exceed 0.3 lb a.i./acre/season. |
| | acephate (Orthene) | 0.5 to 1 lb | 7 days. |
| | dimethoate | 0.25 lb | 0 days. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 1 day at low rate; 4 days at high rate. Do not exceed 2 applications per season. |
| | imidacloprid (Provado) | 0.05 lb | 0 days. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/ 50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact aphids to be effective. |
| | *methomyl (Lannate) | 0.45 lb | 3 days. |
| | thiamethoxam (Actara) | 0.03 to 0.06 lb | 0 days. Do not exceed 0.125 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **PEPPERS (CONT.)** | | | |
| European corn borer | Treat at about 5-day intervals when peppers are fruiting if light traps are capturing more than 5 to 10 European corn borer moths per night. Likelihood of damage is reduced if nearby corn is suitable for corn borer egg laying. | | |
| | acephate (Orthene) | 1 lb | 7 days. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.1 lb | 7 days. Do not exceed 0.2 lb a.i./acre/season. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 7 days. Allow at least 7 days between applications. Do not exceed 0.26 lb a.i./acre/season. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 5 days. Do not exceed 0.36 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | methoxyfenozide (Intrepid) | 0.12 to 0.25 lb | 1 day. Do not exceed 1 lb a.i./acre/season. |
| | *permethrin (Ambush, Pounce) | 0.2 lb | 3 days. Do not exceed 1.6 lb a.i./acre/season. |
| | spinosad (Entrust, SpinTor) | 0.062 to 0.125 lb | 1 day. Do not exceed 0.45 lb/acre/crop. See label for further resistance-mangement restrictions. |
| | tebufenozide (Confirm) | 0.09 to 0.25 lb | 7 days. Do not exceed 1.0 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.028 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Flea beetle, Colorado potato beetle | acephate (Orthene) | 0.5 lb | 7 days. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.1 lb | 7 days. Do not exceed 0.2 lb a.i./acre/season. |
| | cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 7 days. Do not exceed 0.26 lb a.i./acre/season. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 7 days. Do not exceed 0.35 lb a.i./acre/season. Early-season pest. |
| | imidacloprid (Admire) | See label for rates based on row spacings. | 21 days. Apply to soil as a band or in-furrow treatment at bedding or seeding, as a post-seeding drench, as a sidedress, or in trickle irrigation. |
| | imidacloprid (Provado) | 0.05 lb | 0 days. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. |
| | kaolin (Surround) | 6.25 to 25 lb | 0 days. Apply at 7- to 14-day intervals beginning before infestations occur. Use additional insecticides to supplement control. (This product's primary use is in certified organic production.) |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 5 days. Do not exceed 0.36 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | rotenone | See product label. | 1 day. |
| | spinosad (Entrust, SpinTor) | 0.035 to 0.070 lb | 1 day. Do not exceed 0.45 lb a.i./acre/season. |
| | thiamethoxam (Actara) | 0.03 to 0.06 lb | 0 days. Do not exceed 0.125 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.028 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **PEPPERS (CONT.)** | | | |
| Whiteflies | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | imidacloprid (Provado) | 0.05 lb | 0 days. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/ 50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact whiteflies to be effective. |
| | pyriproxyfen (Knack) | 0.06 to 0.07 lb | 14 days. Do not exceed 3 applications (0.18 lb a.i./acre) per season. Wait at least 14 days between applications. |
| | thiamethoxam (Actara) | 0.03 to 0.06 lb | 0 days. Do not exceed 0.125 lb a.i./acre/season. |
| | Sprays of acetamiprid (Assail), bifenthrin (Capture, Discipline), cyfluthrin (Baythroid), dimeth oate, endosulfan (Thiodan), esfenvalerate (Asana), lambda-cyhalothrin (Warrior), methomyl (Lannate), or zeta-cypermethrin (Fury or Mustang) as listed for aphid or flea beetle control also may control whiteflies. Efficacy is likely to vary according to specific insecticide-resistance levels in separate whitefly populations. | | |
| **POTATOES** | | | |
| Colorado potato beetle; cutworms; flea beetles; potato leafhopper | Populations of Colorado potato beetle are resistant to one or more insecticides in most areas. Field kits for detecting insecticide resistance are available from Michigan State University. Contact the University of Illinois Department of Crop Sciences at (217)333-6651 for information. If registered insecticides fail to give control, switch to another insecticide class. Rotate crops to delay infestations. | | |
| | **Suggested thresholds for potato pests:**<br>Colorado potato beetle—For spring adults on young plants, 20 to 30% defoliation or, more conservatively, 2 adults per plant. Summer larvae and summer adults, during bloom, 5 to 10% defoliation, 5 larvae per plant, or 3 to 5 adults per plant.<br>Cutworms and loopers—For summer foliage feeding, prebloom, 4 per foot of row; post-bloom, 8 per foot of row.<br>Green peach aphid—30 per 100 leaves.<br>Potato aphid—50 per 100 leaves.<br>Potato leafhopper—2 adults per sweep or 1 adult per sweep plus 15 nymphs per 25 leaves.<br>Tarnished plant bug (Lygus bug)—1 per sweep.<br>Miscellaneous defoliators—20% defoliation at flowering; more damage is tolerable before and after bloom. | | |
| | *abamectin (Agri-Mek) | 0.01 to 0.02 lb | 14 days. Do not exceed 2 applications per crop. Use at least 20 gallons water per acre. Do not feed or graze treated foliage. |
| | *Bacillus thuringiensis san diego* (= *Bt tenebrionis*) (Foil, M-Trak, Novodor) | Follow label directions. | 0 days. For Colorado potato beetle only. These strains of *Bt* kill only the early larval stages; they will not kill adults. |
| | carbaryl (Sevin) | 2 lb (cutworms: 4 lb) | 0 days. |
| | *carbofuran (Furadan) | 0.5 to 1 lb | 14 days. Do not apply more than 8 times per season. Not labeled for cutworms. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **POTATOES (CONT.)** | | | |
| Colorado potato beetle; cutworms; flea beetles; potato leafhoppers (cont.) | cryolite (Kryocide and others) | 10 to 12 lb | 0 days. Do not exceed 96 lb/acre/season. |
| | cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days. Do not exceed 0.26 lb a.i./acre/season. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 1 day. Do not exceed 6 applications or 6 lb a.i./acre/season. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 7 days. Do not exceed 0.35 lb a.i./acre/season. |
| | imidacloprid (Admire) | 0.18 to 0.31 lb | Apply at planting to seed pieces in-furrow or according to label as a bedding, sidedress, or hilling application. Rate varies with row spacing. |
| | imidacloprid (Provado) | 0.05 lb | 7 days. Allow at least 7 days between applications. Do not exceed 0.2 lb a.i./acre/season. Do not use Provado as a foliar spray if Admire was used at planting. |
| | kaolin (Surround) | 6.25 to 25 lb | 0 days. Apply at 7- to 14-day intervals beginning before infestations occur. Use additional insecticides to supplement control. (This product's primary use is in certified organic production.) |
| | novaluron (Rimon) | 0.06 to 0.08 lb | 14 days. Do not exceed 24 oz product/acre/season. |
| | *oxamyl (Vydate) | 2 to 4 lb | In seed furrow at planting in a minimum of 20 gal. water/acre. |
| | | 0.5 to 1 lb | 7 days. Foliar spray. |
| | *permethrin (Ambush, Pounce) | 0.05 to 0.2 lb | 7 days. Do not exceed 2.4 lb a.i./acre/season. |
| | *phorate (Thimet G) | 2 to 3 lb | 90 days. Place at side(s) of row at planting but not in direct contact with seed pieces. Low flea rate on light soils; high rate on heavier soils; do not use on muck soils. Not labeled for cutworms. Also aids in aphid control. |
| | phosmet (Imidan) | 1 lb | 7 days. For machine-harvested fields only. |
| | rotenone | Follow label directions. | 1 day. For Colorado potato beetle and flea beetles. |
| | spinosad (Entrust, SpinTor) | 0.047 to 0.094 lb | 7 days. Do not exceed 0.33 lb a.i./acre/season. SpinTor may be applied by chemigation. |
| | thiamethoxam (Actara) | 0.03 to 0.06 lb | 14 days. Do not exceed 0.125 lb a.i./acre/season. |
| | thiamethoxam (Platinum) | See label for rate conversion chart. | Apply at planting or at plant emergence. See label for restrictions. |
| Aphids | dimethoate | 0.25 to 0.5 lb | 0 days. Also controls leafhoppers. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 1 day. Do not exceed 6 applications or 6 lb a.i./acre/season. |
| | imidacloprid (Admire) | 0.18 to 0.31 lb | Apply at planting to seed pieces in-furrow, or according to label as a bedding, sidedress, or hilling application. Rate varies with row spacing. |
| | imidacloprid (Provado) | 0.05 lb | 7 days. Allow at least 7 days between applications. Do not exceed 0.2 lb a.i./acre/season. Do not use Provado as a foliar spray if Admire was used at planting. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **POTATOES (CONT.)** | | | |
| Aphids (cont.) | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/ 50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact aphids to be effective. |
| | *methomyl (Lannate) | 0.45 to 0.9 lb | 6 days. Also controls leafhoppers and flea beetles. |
| | *oxamyl (Vydate) | 0.5 to 1 lb | 7 days. Foliar spray. |
| | pymetrozine (Fulfill) | 0.086 lb | 14 days. Wait at least 7 days between applications; do not exceed 2 applications per season. |
| | thiamethoxam (Actara) | 0.03 to 0.06 lb | 14 days. Do not exceed 0.125 lb a.i./acre/season. |
| Blister beetles | carbaryl (Sevin) | 0.5 to 1 lb | 0 days. |
| | rotenone | Follow label directions. | 1 day. |
| Wireworms and white grubs | *phorate (Thimet G) | 2 to 3 lb | 90 days. Place at side(s) of row at planting but not in direct contact with seed pieces. Low rate on light soils; high rate on heavier soils; do not use on muck soils. |
| **SWEET CORN** | | | |
| Corn rootworms | Crop rotation (with corn following any crop except corn) usually prevents root damage from corn rootworms. However, in east-central Illinois, corn (including sweet corn) planted in rotation with soybeans and perhaps other crops may be damaged by rootworm larvae that hatch in the late spring and early summer from eggs laid either in rotational crops or in corn crops during the preceding summer and fall. Corn rootworm control may therefore be necessary in crops during the preceding summer and fall. Corn rootworm control may therefore be necessary in "first-year" sweet corn in east-central Illinois. See the field corn guidelines in Chapter 1, "Insect Pest Management for Field and Forage Crops," for more information on this topic. In continuous corn, apply a soil insecticide for rootworm control if no earworm or corn borer control programs were followed last year during silking and ear fill. (Where foliar insecticides were used fairly often for earworms or corn borers in sweet corn, they also controlled rootworm beetles and prevented egg laying.) | | |
| | chlorpyrifos (Lorsban G) | 1 lb | In-furrow or band at planting. |
| | *cyfluthrin plus tebupirimphos (Aztec) | See label. | In-furrow or band at planting. |
| | *phorate (Thimet G) | 1 lb | In-furrow or band at planting. |
| | *tefluthrin (Force 1.5G and 3G) | See label for rates based on row spacings. | In-furrow or band at planting. |
| | *terbufos (Counter G) | 1 lb | In-furrow or band at planting. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **SWEET CORN (CONT.)** | | | |
| Cutworms | Use postemergence sprays at the 3- to 5-leaf stage if 3% of plants are cut and cutworms are still feeding. Ground applications to the base of plants are most effective. | | |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day. Do not exceed 0.2 lb a.i./acre/season. |
| | chlorpyrifos (Lorsban) | 1 to 1.5 lb | 35 days. |
| | *cyfluthrin (Baythroid) | 0.0125 to 0.025 lb | 0 days. No more than 10 applications/crop. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 1 day. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 1 day. Do not exceed 0.48 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 1 day. Do not exceed 1.2 lb a.i./acre/season. |
| Flea beetles | Use varieties that are resistant to Stewart's wilt to reduce the impact of pathogen transmission. Seed treatments that contain Cruiser (thiamethoxam) or Gaucho (imidacloprid) give some systemic control of flea beetles and reduce transmission of Stewart's wilt bacteria. | | |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 1 to 2 lb | 2 days. |
| | *carbofuran (Furadan) | 2.5 fl oz Furadan 4F/1,000 row ft | Apply in-furrow at planting. Apply if overwintering flea beetle populations are high and varieties that are susceptible to Stewart's wilt must be used. |
| | chlorpyrifos (Lorsban) | 1 to 1.5 lb | 35 days. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 1 day. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 1 day. Do not exceed 0.48 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 1 day. Do not exceed 1.2 lb a.i./acre/season. |
| Japanese beetle and corn rootworm beetles | Control beetles if silk clipping threatens pollination. Ground-applied sprays directed to the ear zone are most effective. Sprays (except *Bt* and SpinTor) used for corn earworm or European corn borer also control Japanese beetle and rootworm beetles if they are present. | | |
| | carbaryl (Sevin) | 1 lb | 2 days. |
| European corn borer | Because sweet corn–planting dates vary over a period of several weeks, a range of plant stages may be attacked by first- and second-generation borers (usually in June, then late July to August, respectively). Plant maturity at the time of attack (not the generation of corn borer) determines the type of damage and the appropriate insecticides for control. See also the insecticides listed for corn earworm control if applications are to be made during silking. | | |
| *Whorl-stage corn* | Scout for shot-hole feeding on leaves and for larvae in whorls. Treat during late whorl if more than 15% of plants show larval feeding. Treat before larvae bore from the whorl into the stalk. | | |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **SWEET CORN (CONT.)** | | | |
| European corn borer (cont.) *Whorl-stage corn (cont.)* | *Bacillus thuringiensis kurstaki (Bt)* (Biobit, Cutlass, DiPel, Javelin, MVP, and others) | Follow label directions. | 0 days. Apply granules by air or ground and liquids by ground sprays with nozzles directly over the whorl. *Bt* kills only larvae, not adult moths; ***Bt* does not adequately protect sweet corn if attack occurs during tasseling and ear formation.** |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 2 lb | 2 days. Not as effective as other insecticides listed here. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days. Not more than 10 applications per crop. |
| | indoxacarb (Avaunt) | 0.045 to 0.065 lb | Apply at whorl stage only. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 1 day. Do not exceed 0.48 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.22 to 0.45 lb | 0 days. |
| | methoxyfenozide (Intrepid) | 0.06 to 0.12 lb | 3 days. Do not exceed 1 lb a.i./acre/season. Not labeled for corn earworm control. |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 1 day. Do not exceed 1.2 lb a.i./acre/season. Apply every 5 days as needed. |
| | spinosad (Entrust, SpinTor) | 0.047 to 0.094 lb | 1 day. Do not exceed 0.45 lb a.i./acre/season. May be applied by chemigation. |
| *Tassel emergence through harvest* | Observe light traps for corn borer moths. Treat if counts exceed 10 moths per trap per night. Treat every 5 to 7 days until 10 to 12 days before harvest. | | |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day. Do not exceed 0.20 lb a.i./acre/season. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days. Not more than 10 applications/crop. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 1 day. Do not exceed 0.48 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.23 to 0.45 lb | 0 days. 3 days for forage or grazing. Re-treat at 1- to 3-day intervals. Apply by ground with sprays directed to ear zone. |
| | methoxyfenozide (Intrepid) | 0.06 to 0.12 lb | 3 days. Do not exceed 1 lb a.i./acre/season. Not labeled for corn earworm control. |
| | *methyl parathion (Penncap-M) | 0.5 to 1 lb | 3 days. 12 days forage or grazing. Avoid treating during pollen shed to reduce bee injury. (Not highly effective against corn earworm.) |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 1 day. Do not exceed 1.2 lb a.i./acre/season. Apply every 5 days as needed. |
| | spinosad (Entrust, SpinTor) | 0.047 to 0.094 lb | 1 day. Do not exceed 0.45 lb a.i./acre/season. May be applied by chemigation. |
| | *thiodicarb | 0.5 to 0.75 lb | 0 days. Do not exceed 7.5 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **SWEET CORN (CONT.)** | | | |
| Corn earworm | *Fresh-market corn:* If traps are capturing earworm moths, treat at 2- to 5-day intervals from first silk until 90% or more of the silks are brown (usually 4 to 6 applications). *Processing corn:* If pheromone traps capture more than 10 moths/trap/night, treat at 3- to 6-day intervals from first silk until 90% of the silks are brown. | | |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 2 lb | 2 days. Apply by ground to ear zone. During pollen shed, apply late in the day to reduce bee kill. Sevin XLR is less hazardous to bees than Sevin wettable powder. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days. Not more than 10 applications per crop. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 1 day. Do not exceed 0.5 lb a.i./acre/season. Not effective against European corn borer. |
| | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 1 day. Do not exceed 0.48 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.23 to 0.45 lb | 0 days. 3 days for forage or grazing. Apply by ground to ear zone. |
| | *permethrin (Ambush, Pounce) | 0.1 to 0.2 lb | 1 day. Do not exceed 1.2 lb a.i./acre/season. Apply by ground to ear zone. |
| | spinosad (Entrust, SpinTor) | 0.047 to 0.094 lb | 1 day. Do not exceed 0.45 lb a.i./acre/season. May be applied by chemigation. |
| | *thiodicarb (Larvin) | 0.5 to 0.75 lb | 0 days. Do not exceed 7.5 lb a.i./acre/season. |
| Sap beetle and picnic beetle | carbaryl (Sevin) | 2 lb | 2 days. During pollen shed, apply late in the day to reduce bee kill. Sevin XLR is less hazardous to bees than Sevin wettable powder. |
| | diazinon | 1 lb | 7 days. |
| | malathion | 1 lb | 5 days. |
| Corn leaf aphid | malathion | 1 lb | 5 days. |
| Fall armyworm | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day. Do not exceed 0.20 lb a.i./acre/season. May be applied by chemigation. |
| | *cyfluthrin (Baythroid) | 0.044 lb | 0 days. Not more than 10 applications per crop. |
| | *lambda-cyhalothrin (Warrior) | 0.03 lb | 1 day. Do not exceed 0.48 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.45 lb | 0 days; 3 days for forage or grazing. Apply by ground to ear zone. |
| | spinosad (Entrust, SpinTor) | 0.023 to 0.094 lb | 1 day. Do not exceed 0.45 lb a.i./acre/season. May be applied by chemigation. |
| | *thiodicarb (Larvin) | 0.5 to 0.75 lb | 0 days. Do not exceed 7.5 lb a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **SWEET POTATOES** | | | |
| Wireworms | chlorpyrifos (Lorsban) | 2 lb | Broadcast and immediately incorporate before planting. |
| | diazinon | 3 to 4 lb | Broadcast and immediately incorporate before planting. |
| Flea beetles | carbaryl (Sevin) | 1 to 2 lb | 0 days. See label for notes on sweet potato weevil control. |
| | endosulfan (Thiodan) | 0.5 lb | 0 days. Do not exceed 3 applications or 3 lb a.i./acre/season. See label for notes on sweet potato weevil control. |
| Sweet potato weevil | Notify the University of Illinois Department of Crop Sciences, (217)333-6651, if the sweet potato weevil, a serious pest in southern states, is detected in Illinois fields. | | |
| **TOMATOES AND EGGPLANTS** | | | |
| Cutworms | Treat transplants if infestations exceed 1 larva per 10 plants. | | |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day for tomatoes. 7 days for eggplant. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 2 lb | 3 days. |
| | *cyfluthrin (Baythroid) | 0.044 lb | 0 days. Allow 7 days between applications. Do not exceed 6 applications per season. Do not apply to eggplant. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 1 day for tomato; 7 days for eggplant. Do not feed or graze treated vines. Do not exceed 0.5 lb a.i./acre/season. |
| | *lambda-cyhalothrin (Warrior) | 0.015 to 0.025 lb | 5 days for tomato and tomatillo. Do not exceed 0.36 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.45 lb | 1 day for tomato; 5 days for eggplant. |
| | spinosad (Entrust, SpinTor) | 0.023 to 0.125 lb | 1 day. Do not exceed 0.45 lb/acre/crop. See label for further resistance-management restrictions. |
| | tebufenozide (Confirm) | 0.09 to 0.25 lb | 7 days. Do not exceed 1.0 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.028 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Flea beetles | Treat if infestations exceed 2 beetles per 10 leaves. | | |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day for tomatoes. 7 days for eggplant. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 2 lb | 3 days. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 2 days. Do not exceed 3.0 lb a.i./acre/season. |
| | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 1 day for tomato; 7 days for eggplant. Do not feed or graze treated vines. Do not exceed 0.5 lb a.i./acre/season. |
| | imidacloprid (Admire) | See label for rates based on row spacings. | 21 days. |
| | imidacloprid (Provado) | 0.05 lb | 0 days. Allow at least 5 days between applications. Do not exceed 0.24 a.i./acre/season. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **TOMATOES AND EGGPLANTS (CONT.)** | | | |
| Flea beetles (cont.) | kaolin (Surround) | 6.25 to 25 lb | 0 days. Apply at 7- to 14-day intervals beginning before infestations occur. Use additional insecticides to supplement control. (This product's primary use is in certified organic production.) |
| | *lambda-cyhalothrin (Warrior) | 0.015 to 0.025 lb | 5 days. Do not exceed 0.36 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | rotenone | See product label. | 1 day. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.028 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Aphids | Treat if 25 to 50% of plants are infested by wingless aphids; count only wingless aphids that indicate colonies have started. | | |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days. Allow 7 days between applications. Do not exceed 6 applications per season. Do not apply to eggplant. |
| | diazinon | 0.25 lb | 1 day for tomato. Do not apply to eggplant. |
| | dimethoate | 0.25 lb | 7 days for tomato. Do not apply to eggplant. |
| | imidacloprid (Admire) | See label for rates based on row spacings. | 21 days. |
| | imidacloprid (Provado) | 0.05 lb | 0 days. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/ 50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact aphids to be effective. |
| | malathion | 1 lb | 1 day for tomato; 3 days for eggplant. |
| | *methomyl (Lannate) | 0.45 to 0.9 lb | 1 day for tomato; 5 days for eggplant. |
| | pymetrozine (Fulfill) | 0.09 lb | 0 days. |
| Corn earworm; European corn borer; hornworm; cabbage looper | Treat to control corn earworm (tomato fruitworm) when tomatoes are fruiting and pheromone-baited cone traps capture 20 or more moths per night. Treatment may be delayed if no eggs are present on leaves. Moths deposit few eggs in tomatoes if nearby corn is silking. | | |
| | *Bacillus thuringiensis kurstaki* or *aizawai (Bt)* (Agree, Biobit, Cutlass, DiPel, Javelin, MVP, XenTari, and others) | Follow label directions. | 0 days. Kills caterpillar stage (larvae) only, not adult moths; larvae must eat treated foliage. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day for tomatoes. 7 days for eggplant. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 2 lb | 3 days. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days for tomato. Allow at least 7 days between applications. Do not exceed 0.26 lb a.i./acre/season. Do not use on eggplant. |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **TOMATOES AND EGGPLANTS (CONT.)** | | | |
| Corn earworm, European corn borer; hornworm; cabbage looper (cont.) | *esfenvalerate (Asana) | 0.03 to 0.05 lb | 1 day for tomato; 7 days for eggplant. Do not feed or graze treated vines. Do not exceed 0.5 lb a.i./acre/season. |
| | fenpropathrin (Danitol) | 0.2 lb | 3 days. Do not exceed 0.8 lb a.i./acre/season. |
| | indoxacarb (Avaunt) | 0.045 to 0.065 lb | 3 days. Do not exceed 0.26 lb a.i./acre/season. |
| | kaolin (Surround) | 6.25 to 25 lb | 0 days. Apply at 7- to 14-day intervals beginning before infestations occur. Use additional insecticides to supplement control. (This product's primary use is in certified organic production.) |
| | *lambda-cyhalothrin (Warrior) | 0.015 to 0.025 lb | 5 days. Do not exceed 0.36 lb a.i./acre/season. Proaxis (gamma-cychalothrin) also is registered. See the label for rates and restrictions. |
| | *methomyl (Lannate) | 0.45 to 0.9 lb | 1 day for tomato; 5 days for eggplant. |
| | spinosad (Entrust, SpinTor) | 0.062 to 0.125 lb | 1 day. Do not exceed 0.45 lb/acre/crop. See label for further restrictions for resistance management. |
| | tebufenozide (Confirm) | 0.09 to 0.25 lb | 7 days. Do not exceed 1.0 lb a.i./acre/season. Not labeled against corn earworm/tomato fruitworm. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.028 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Colorado potato beetle | *abamectin (Agri-Mek) | 0.01 to 0.02 lb | 7 days for tomato. Do not exceed 0.056 lb a.i./acre/season. Do not use on eggplant. |
| | *Bacillus thuringiensis tenebrionis* (Novodor) | 1 to 4 qt formulated product/acre. | 0 days. Apply against young larvae. |
| | *bifenthrin (Capture, Discipline) | 0.033 to 0.10 lb | 1 day for tomatoes. 7 days for eggplant. Do not exceed 0.20 lb a.i./acre/season. |
| | carbaryl (Sevin) | 1 to 2 lb | 3 days. |
| | cryolite (ProKil) | 10 to 16 lb | 14 days. Do not exceed 64 lb a.i./acre/season. |
| | *cyfluthrin (Baythroid) | 0.025 to 0.044 lb | 0 days. Allow 7 days between applications. Do not exceed 6 applications per season. Do not use on eggplant. |
| | diazinon | 0.5 lb | 1 day for tomato. Do not use on eggplant. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 2 days. Do not exceed 3.0 lb a.i./acre/season. |
| | *esfenvalerate (Asana) | 0.05 lb | 1 day for tomato; 7 days for eggplant. Do not feed or graze treated vines. Do not exceed 0.5 lb a.i./acre/season. |
| | imidacloprid (Admire) | 16 to 24 fl oz formulated product/acre. See label for application rates and methods. | 21 days. 1 application/season. |
| | imidacloprid (Provado) | 0.03 to 0.05 lb | 0 days. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. |
| | kaolin (Surround) | 6.25 to 25 lb | 0 days. Apply at 7- to 14-day intervals beginning before infestations occur. Use additional insecticides to supplement control. (This product's primary use is in certified organic production.) |

**Table 1. Insecticides recommended for the control of insects in commercial vegetable crops (cont.)**

| Crop, pest | Insecticide | Rate (a.i./acre) | Preharvest interval (PHI), comments |
|---|---|---|---|
| **TOMATOES AND EGGPLANTS (CONT.)** | | | |
| Colorado potato beetle (cont.) | *lambda-cyhalothrin (Warrior) | 0.02 to 0.03 lb | 5 days. Do not exceed 0.36 lb a.i./acre/season. Proaxis (gamma-cyhalothrin) also is registered. See the label for rates and restrictions. |
| | spinosad (Entrust, SpinTor) | 0.035 to 0.070 lb | 1 day. Use against larvae. Do not exceed 0.45 lb/acre/crop. See label for further resistance-management restrictions. |
| | thiamethoxam (Actara) | 0.03 to 0.06 lb | 0 days. Do not exceed 0.125 lb a.i./acre/season. |
| | *zeta-cypermethrin (Fury, Mustang) | 0.028 to 0.05 lb | 1 day. Do not exceed 0.3 lb a.i./acre/season. |
| Spider mites | *abamectin (Agri-Mek) | 0.01 to 0.02 lb | 7 days for tomato. Do not use on eggplant. |
| | bifenazate (Acramite) | 0.4 to 0.5 lb | 3 days. One application per season. |
| | *bifenthrin (Capture, Discipline) | 0.08 to 0.10 lb | 1 day for tomatoes. 7 days for eggplant. Do not exceed 0.20 lb a.i./acre/season. |
| | dicofol (Kelthane MF) | 0.5 to 0.75 lb | 2 days for tomato. Do not exceed 2 applications per season. Do not use on eggplant. |
| | dimethoate | 0.25 lb | 7 days for tomato. Do not use on eggplant. |
| | fenpropathrin (Danitol) | 0.2 lb | 3 days. Do not exceed 0.8 lb a.i./acre/season. |
| Fruit flies and picnic beetle | Late-season pests (August to October). Treat to prevent fruit damage if pests are present. | | |
| | carbaryl (Sevin) | 2 lb | 3 days. |
| | diazinon | 0.5 lb | 1 day for tomato. Do not apply to eggplant. |
| Whiteflies | azadirachtin (Align, Neemix) | 10 to 20 g (See labels.) | 0 days. |
| | endosulfan (Thiodan) | 0.5 to 1 lb | 1 day. Do not exceed 6 applications or 3 lb a.i./acre/season. |
| | imidacloprid (Admire) | See label for rates based on row spacings. | 21 days. Apply to soil as a sidedress or in trickle irrigation in late season as whiteflies appear. |
| | imidacloprid (Provado) | 0.5 lb | 0 days. Allow at least 5 days between applications. Do not exceed 0.24 lb a.i./acre/season. |
| | insecticidal soap (M-Pede) | 1.25 fl oz 49% concentrate/50 gal. water (See comments.) | 0 days. Use sufficient spray to wet all infested plant surfaces. Rotate sprays or rinse foliage to avoid more than 3 consecutive sprays. Must contact whiteflies to be effective. |
| | pyriproxyfen (Knack) | 0.06 to 0.07 lb | 14 days. Do not exceed 3 applications (0.18 lb a.i./acre) per season. Wait at least 14 days between applications. |
| | thiamethoxam (Actara) | 0.03 to 0.06 lb | 0 days. Do not exceed 0.125 lb a.i./acre/season. |
| | Sprays of bifenthrin (Capture, Discipline) (eggplant only), dimethoate, esfenvalerate (Asana), fenpropathrin (Danitol), or methomyl (Lannate) as listed for aphid or flea beetle control also may control whiteflies. Efficacy is likely to vary according to specific insecticide-resistance levels in separate whitefly populations. | | |

*Use restricted to certified (licensed) applicators only.

In addition to the use of insecticides, integrated pest management programs for vegetable insects should include appropriate cultural practices (such as the selection of resistant varieties, the purchase of insect-free transplants, and the destruction of crop residues after harvest) and the use of alternatives to chemical insecticides when possible. Although using effective cultural and biological control options does not eliminate the need for conventional insecticides, the application of such products can be reduced on farms where an integrated approach is practiced.

## Pest Management in Greenhouse Vegetable and Herb Production

Managing insect and mite pests on vegetables and herbs grown in greenhouses can be especially challenging because the pest species may be unique to greenhouses, but many of the insecticides and miticides used for their control on other greenhouse plants are not labeled for application to vegetables or herbs. For any pesticide to be applied to vegetables or herbs, in the greenhouse or outdoors, the pesticide must be labeled for use on the specific crop.

Vegetables grown in greenhouses, which include tomatoes, peppers, eggplants, cucumbers, and others (as well as a variety of seedlings grown for transplant into fields), are susceptible to attack by a variety of insects and mites. Herbs grown in greenhouses, which include basil, chives, lavender, mint, parsley, rosemary, sage, and thyme, are also subject to attack by a variety of insects and mites. The common insect and mite pests of greenhouse-grown plants are aphids, thrips, fungus gnats, shore flies, spider mites, whiteflies, leafminers, and caterpillars. Because these pests may move from flowers and other ornamental plants to vegetables and herbs, and because the insecticides used to control them are not labeled for use on vegetables or herbs, it usually is best to use a separate greenhouse for crops.

Keys to successful management of greenhouse pests include cultural controls, monitoring, pesticides, and biological controls.

### Cultural Management

Cultural management strategies (production practices) are important in preventing pest problems. Maintaining ideal environmental conditions (light, humidity, and temperature) and providing optimum levels of water and fertility avoid stressing vegetable seedlings/transplants. Stressed plants are more susceptible to some insects and mites. Keep the greenhouse clean of all plant and growing-medium debris. Remove plants that are heavily infested with insects or mites. Put them into plastic bags and dispose of them away from the greenhouse. Removing older leaves from plants may be effective in eliminating certain stages (eggs and pupae) of pests such as whiteflies, leafminers, and spider mites. Eliminate all weeds within and around the greenhouse perimeter. Weeds serve as a reservoir for thrips, whiteflies, and aphids. Insects can migrate into greenhouses from weeds located outside openings such as vents, sidewalls, and doorways. In addition, many weeds are sources of viruses. Tomato and pepper transplants are very susceptible to viruses such as impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV). Both of these viruses are transmitted by thrips.

Insect-proof screens covering openings such as vents and sidewalls are useful in reducing the movement of insects into greenhouses. Whiteflies, winged aphids, leafminers, and moths can be excluded effectively with screening. However, thrips are more difficult to keep out because of their small size. The appropriate screen size for thrips is 192 microns (132 mesh). When using screens, it is necessary to increase the screen size area over openings in the greenhouse to compensate for reduced airflow. Screens must be cleaned regularly to remove debris, which may reduce airflow. Screening greenhouses is effective only when used with other management strategies.

### Monitoring

Monitoring (scouting) is essential in all pest-management programs. Monitoring helps detect infestations early, which makes control easier. In addition, effective monitoring will determine population trends throughout the growing season. Common methods include the use of traps and simple visual inspection of plants. Yellow sticky cards are trapping devices that are generally placed vertically just above or within the crop canopy. Sticky cards detect the adult stages of thrips, whiteflies, leafminers, shore flies, caterpillars (moths), and fungus gnats. Fungus gnat adults are best detected by placing yellow sticky cards horizontally near the growing medium, which is where fungus gnat adults tend to reside. Sticky cards also capture parasitic wasps and predatory beetles.

Place yellow sticky cards uniformly throughout the crop using two sticky cards per 1,000 square feet. It is especially important to place sticky cards near vents, sidewalls, and doors, as these are locations where insects can enter a greenhouse. Sticky cards should be checked once a week and the number of insects counted and recorded. A 10x hand lens can be used to identify small insects.

*(Text continues on page 232.)*

**Table 2. Minimum preharvest intervals (in days) of common insecticides registered for use on vegetable crops**

| | *abamectin (Agri-Mek) | acephate (Orthene) | acetamiprid (Assail) | azadirachtin (Align, Neemix) | *azinphosmethyl (Guthion) | *Bacillus thuringiensis aizawai* | *Bacillus thuringiensis kurstaki* | *Bacillus thuringiensis san diego (tenebrionis)* | bifenazate (Acramite) | *bifenthrin (Capture, Discipline) | carbaryl (Sevin) | *carbofuran (Furadan) | chlorpyrifos (Lorsban) | cryolite (Kryocide, ProKil) | *cyfluthrin (Baythroid) | *cypermethrin (Ammo) | diazinon (D-Z-N) | dicofol (Kelthane) | dimethoate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asparagus | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | ... | 1 | ... | 1 | ... | ... | ... | ... | ... | ... |
| Beans (snap) | ... | 14 | ... | 0 | ... | 0 | 0 | ... | ... | 3 | 3 | ... | ... | ... | ... | ... | 7 | 7 | 0 |
| Beets | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | ... | 3 | ... | ... | ... | ... | ... | 14 | ... | ... |
| Broccoli | ... | ... | 7 | 0 | 15 | 0 | 0 | ... | ... | 7 | 3 | ... | 30 | 7 | ... | 1 | 7 | ... | 7 |
| Brussels sprouts | ... | 14 | 7 | 0 | 7 | 0 | 0 | ... | ... | 7 | 3 | ... | 21 | 7 | ... | 1 | 7 | ... | ... |
| Cabbage | ... | ... | 7 | 0 | 21 | 0 | 0 | ... | ... | 7 | 3 | ... | 30 | S | ... | 1 | 21 | ... | 7 |
| Carrots | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | 7 | ... | ... | ... | ... | 0 | ... | 14 | ... | ... |
| Cauliflower | ... | 14 | 7 | 0 | 15 | 0 | 0 | ... | ... | 7 | 3 | ... | 30 | 7 | ... | 1 | 7 | ... | 7 |
| Celery | 7 | 21 | 7 | 0 | 14 | 0 | 0 | ... | ... | ... | 14 | ... | ... | ... | ... | ... | ... | ... | ... |
| Chinese cabbage | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | 7 | 14 | ... | 30 | ... | ... | 1 | 10 | ... | ... |
| Collards | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | ... | 14 | ... | 21 | S | ... | 1 | 10 | ... | 14 |
| Cucumber | 7 | ... | ... | 0 | 1 | 0 | 0 | ... | 3 | 3 | 3 | P | ... | X | ... | 7 | 7 | ... | ... |
| Eggplant | ... | ... | 7 | 0 | 21 | 0 | 0 | 0 | 3 | 7 | 3 | ... | ... | ... | ... | ... | ... | ... | ... |
| Endive, escarole | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | ... | 14 | ... | ... | ... | ... | ... | 14 | ... | 14 |
| Horseradish | ... | ... | ... | 0 | ... | 0 | 0 | 0 | ... | ... | 3 | ... | ... | ... | ... | ... | ... | ... | ... |
| Kale | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | ... | 14 | ... | 21 | ... | ... | 1 | 10 | ... | 14 |
| Kohlrabi | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | 7 | 3 | ... | 21 | ... | ... | 1 | ... | ... | ... |
| Lettuce (leaf) | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | ... | 14 | ... | ... | S | ... | ... | 14 | ... | 14 |
| Melons | 7 | ... | ... | 0 | 7 | 0 | 0 | ... | 3 | 3 | 3 | P | ... | 14 | ... | ... | 3 | 2 | 3 |
| Mustard greens | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | ... | 14 | ... | ... | S | ... | 1 | 10 | ... | 14 |
| Onion, bulb | ... | ... | ... | 0 | 28 | 0 | 0 | ... | ... | ... | ... | P | P | ... | ... | 7 | 7 | 14 | ... |
| Onion, green | ... | ... | ... | 0 | 14 | 0 | 0 | ... | ... | ... | ... | ... | ... | ... | ... | 7 | 14 | ... | ... |
| Parsley | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | ... | 14 | ... | ... | ... | ... | ... | X | ... | ... |
| Parsnip | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | ... | 3 | ... | ... | ... | ... | ... | 14 | ... | ... |
| Peas | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | 3 | 21 | ... | ... | ... | ... | ... | 7 | 0 | ... |
| Pepper | 7 | 7 | 7 | 0 | ... | 0 | 0 | ... | 3 | 7 | 3 | ... | ... | 14 | 7 | ... | 5 | 2 | 0 |
| Potato | 14 | ... | ... | 0 | 7 | 0 | 0 | 0 | ... | ... | 0 | 14 | ... | 0 | 0 | ... | 35 | ... | 0 |
| Pumpkin | 7 | ... | ... | 0 | ... | 0 | 0 | ... | 3 | 3 | 3 | P | ... | .... | ... | ... | ... | 2 | ... |
| Radish | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | ... | 7 | ... | P | ... | 0 | ... | 14 | ... | ... |
| Rhubarb | ... | ... | 7 | 0 | ... | 0 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Rutabaga | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | ... | 3 | ... | P | ... | ... | ... | ... | ... | ... |
| Spinach | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | 40 | 14 | ... | ... | ... | ... | ... | 14 | ... | 14 |
| Squash, summer | 7 | ... | ... | 0 | ... | 0 | 0 | ... | 3 | 3 | 3 | P | ... | 7 | ... | ... | 7 | 2 | ... |
| Squash, winter | 7 | ... | ... | 0 | ... | 0 | 0 | ... | 3 | 3 | 3 | P | ... | 14 | ... | ... | 3 | 2 | ... |
| Sweet corn | ... | ... | ... | ... | .. | ... | 0 | ... | ... | 1 | 2 | 7 | 35 | ... | 0 | ... | 7 | ... | ... |
| Sweet potato | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | ... | 0 | ... | P | ... | ... | ... | P | ... | ... |
| Swiss chard | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | ... | 14 | ... | ... | ... | ... | ... | 14 | ... | 14 |
| Tomato | 7 | ... | 7 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | ... | ... | 14 | 0 | ... | 1 | 2 | 7 |
| Turnip, roots | ... | ... | ... | 0 | ... | 0 | 0 | ... | ... | ... | 7 | ... | P | ... | ... | ... | 14 | ... | 14 |
| Turnip, tops | ... | ... | 7 | 0 | ... | 0 | 0 | ... | ... | ... | 14 | ... | P | ... | ... | ... | 14 | ... | 14 |

Preharvest intervals (PHIs) listed are minimums; at maximum application rates, the PHI for some products is greater than the period indicated here. Additional restrictions (limiting the total number of applications or restricting the use of treated plants for livestock feed) also may apply. S = apply to seeds or seedlings only; P = apply at or before planting or as early-season sidedress according to label; X = preharvest interval not specified; . . . = not registered for use on this crop.
*Use restricted to certified (licensed) applicators.

**Table 2. Minimum preharvest intervals (in days) of common insecticides registered for use on vegetable crops (cont.)**

| | disulfoton (Di-Syston) | *emamectin benzoate (Proclaim) | endosulfan (Thiodan) | *esfenvalerate (Asana) | fenpropathrin (Danitol) | *gamma-cyhalothrin (Proaxis) | imidacloprid (Admire, Provado) | indoxacarb (Avaunt) | kaolin (Surround) | *lambda-cyhalothrin (Warrior) | lindane (Isotox) | malathion (Cythion, Malathion) | metaldehyde | methamidaphos (Monitor) | *methomyl (Lannate) | *methyl parathion (Penncap-M) | naled (Dibrom) | novaluron (Rimon) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asparagus | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | X | ... | 1 | ... | ... | ... |
| Beans (snap) | P | ... | 3 | 3 | ... | 1 | 7 | ... | ... | 1 | S | 1 | X | ... | 3 | ... | 1 | ... |
| Beets | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 7 | X | ... | 0 | 15 | ... | ... |
| Broccoli | P | 7 | 7 | 3 | 7 | 1 | 7 | 3 | ... | 1 | S | 3 | X | ... | 3 | ... | 1 | ... |
| Brussels sprouts | P | 7 | 14 | ... | 7 | 1 | 7 | 3 | ... | 1 | S | 7 | X | ... | 3 | ... | 1 | ... |
| Cabbage | P | 7 | 7 | 3 | 7 | 1 | 7 | 3 | ... | 1 | S | 7 | X | ... | 1 | ... | 1 | ... |
| Carrots | ... | ... | 7 | 7 | ... | ... | ... | ... | ... | ... | 7 | X | ... | 1 | 14 | ... | ... | ... |
| Cauliflower | P | 7 | 14 | 3 | 7 | 1 | 7 | 3 | ... | 1 | S | 7 | X | ... | 3 | ... | 1 | ... |
| Celery | ... | 7 | 7 | ... | ... | ... | P | ... | ... | ... | S | 7 | X | ... | 7 | ... | 1 | ... |
| Chinese cabbage | P | 7 | ... | 3 | ... | ... | 7 | 3 | ... | ... | ... | ... | ... | ... | 10 | ... | ... | ... |
| Collards | ... | 14 | 21 | 7 | ... | ... | 7 | ... | ... | ... | S | 7 | X | ... | 10 | ... | 1 | ... |
| Cucumber | ... | ... | 0 | 3 | 7 | ... | 21 | ... | 0 | ... | S | 1 | X | ... | 1 | ... | ... | ... |
| Eggplant | ... | 7 | 1 | 7 | ... | 5 | 0 | 3 | 0 | 5 | ... | 3 | X | ... | 5 | ... | 1 | ... |
| Endive, escarole | ... | 7 | ... | ... | ... | ... | 7 | ... | ... | ... | ... | 7 | X | ... | 10 | ... | ... | ... |
| Horseradish | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 7 | X | ... | 65 | ... | ... | ... |
| Kale | ... | 14 | 21 | ... | ... | ... | 7 | ... | ... | ... | S | 7 | X | ... | 10 | ... | 1 | ... |
| Kohlrabi | ... | 7 | ... | ... | 7 | ... | 7 | 3 | ... | ... | ... | 7 | X | ... | ... | ... | ... | ... |
| Lettuce (leaf) | P | 7 | 14 | ... | ... | 1 | 7 | 3 | ... | 1 | P | 14 | X | ... | ... | ... | ... | ... |
| Melons | ... | ... | 0 | 3 | 7 | ... | 21 | ... | 0 | ... | S | 1 | X | ... | 1 | ... | ... | ... |
| Mustard greens | ... | 14 | 21 | ... | .... | ... | 7 | ... | ... | ... | ... | 7 | X | ... | 10 | ... | ... | ... |
| Onion, bulb | ... | ... | ... | ... | ... | 14 | ... | ... | 0 | 14 | ... | 3 | X | ... | 7 | 15 | ... | ... |
| Onion, green | ... | ... | ... | ... | ... | ... | ... | 0 | ... | ... | 3 | X | ... | 7 | ... | ... | .. | ... |
| Parsley | ... | 7 | ... | ... | ... | ... | 7 | ... | ... | ... | ... | 21 | ... | ... | 10 | ... | ... | ... |
| Parsnip | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 7 | X | ... | ... | ... | ... | ... |
| Peas | ... | ... | 0 | 3 | ... | 7 | ... | ... | ... | 7 | ... | 3 | X | ... | 1 | ... | 1 | ... |
| Pepper | ... | 7 | 1 | 7 | ... | 5 | 0 | 3 | 0 | 5 | ... | 3 | X | ... | 3 | ... | 1 | ... |
| Potato | 30 | ... | 1 | 7 | ... | ... | 7 | ... | ... | ... | ... | 0 | X | 14 | 6 | 5 | ... | 14 |
| Pumpkin | ... | ... | 0 | 3 | 7 | ... | 21 | ... | 0 | ... | S | 3 | X | ... | ... | ... | ... | ... |
| Radish | ... | ... | ... | 7 | ... | .... | .. | ... | ... | ... | ... | 7 | X | ... | ... | ... | ... | ... |
| Rhubarb | ... | 7 | ... | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Rutabaga | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3 | X | ... | ... | ... | ... | ... |
| Spinach | ... | 7 | 21 | ... | ... | ... | 7 | ... | ... | ... | S | 7 | X | ... | 7 | ... | ... | ... |
| Squash, summer | ... | ... | 0 | 3 | 7 | ... | 21 | ... | 0 | ... | S | 1 | X | ... | 1 | ... | 1 | ... |
| Squash, winter | ... | ... | 0 | 3 | 7 | ... | 21 | ... | 0 | ... | S | 1 | X | ... | ... | ... | ... | ... |
| Sweet corn | ... | ... | 0 | 1 | ... | 1 | ... | 3 | ... | 1 | ... | 5 | X | ... | 0 | 3 | ... | ... |
| Sweet potato | ... | ... | 0 | ... | ... | ... | P | ... | ... | ... | ... | ... | X | ... | ... | ... | ... | 14 |
| Swiss chard | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | ... | 7 | X | ... | 10 | ... | ... | ... |
| Tomato | P | 7 | 1 | 1 | 2 | 5 | 0 | 3 | 0 | 5 | P | 1 | X | ... | 1 | ... | ... | ... |
| Turnip, roots | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 7 | X | ... | 10 | ... | ... | ... |
| Turnip, tops | ... | 14 | 21 | ... | ... | ... | 7 | ... | ... | ... | ... | 7 | X | ... | ... | ... | ... | ... |

Preharvest intervals (PHIs) listed are minimums; at maximum application rates, the PHI for some products is greater than the period indicated here. Additional restrictions (limiting the total number of applications or restricting the use of treated plants for livestock feed) also may apply. S = apply to seeds or seedlings only; P = apply at or before planting or as early-season sidedress according to label; X = preharvest interval not specified; . . . = not registered for use on this crop.

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**Table 2. Minimum preharvest intervals (in days) of common insecticides registered for use on vegetable crops (cont.)**

| | *oxamyl (Vydate) | *permethrin (Ambush, Permethrin, Pounce) | *phorate (Thimet) | potassium salt soap (M-Pede) | pymetrozine (Fulfill) | pyrethrins plus PBO | pyriproxyfen (Knack) | rotenone | spinosad (Entrust, SpinTor) | tebufenozide (Confirm) | *tefluthrin (Force) | *terbufos (Counter) | thiamethoxam (Actara, Platinum) | thiodicarb (Larvin) | *tralomethrin (Scout X-tra) | *zeta-cypermethrin (Fury, Mustang) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asparagus | ... | 1 | ... | 0 | ... | 0 | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... |
| Beans (snap) | ... | ... | P | 0 | ... | 0 | ... | 1 | 3 | ... | ... | ... | ... | ... | ... | 1 |
| Beets | ... | ... | ... | 0 | ... | 0 | ... | 1 | 3 | ... | ... | ... | ... | ... | ... | ... |
| Broccoli | ... | 1 | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | 7 | 5 | 1 |
| Brussels sprouts | ... | 1 | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | ... | ... | 1 |
| Cabbage | ... | 1 | ... | 0 | 7 | 0 | ... | 1 | 1 | 7 | ... | ... | ... | 7 | ... | 1 |
| Carrots | P | ... | ... | 0 | ... | 0 | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... |
| Cauliflower | ... | 1 | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | 7 | ... | 1 |
| Celery | 14 | 1 | ... | 0 | 7 | 0 | ... | 1 | 1 | 7 | ... | ... | ... | ... | ... | ... |
| Chinese cabbage | ... | 1 | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | 14 | ... | 1 |
| Collards | ... | 1 | ... | 0 | 7 | 0 | ... | 1 | 1 | 7 | ... | ... | ... | ... | ... | 1 |
| Cucumber | 1 | 0 | ... | 0 | 0 | 0 | ... | 1 | 1 | ... | ... | ... | ... | ... | ... | ... |
| Eggplant | 1 | 3 | ... | 0 | 0 | 0 | ... | 1 | 1 | 7 | ... | ... | ... | ... | ... | 1 |
| Endive, escarole | ... | 1 | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | 14 | ... | ... |
| Horseradish | ... | 22 | ... | 0 | ... | 0 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Kale | ... | ... | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | ... | ... | 1 |
| Kohlrabi | ... | ... | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | ... | ... | 1 |
| Lettuce (leaf) | ... | 1 | ... | 0 | 7 | 0 | ... | 1 | 1 | 7 | ... | ... | ... | 14 | 3 | ... |
| Melons | 1 | 0 | ... | 0 | 0 | 0 | ... | 1 | 3 | ... | ... | ... | ... | ... | ... | ... |
| Mustard greens | ... | ... | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | ... | ... | 1 |
| Onion, bulb | ... | 1 | ... | 0 | ... | 0 | ... | 1 | ... | ... | ... | ... | ... | ... | ... | 7 |
| Onion, green | ... | ... | ... | 0 | ... | 0 | ... | 0 | ... | ... | ... | ... | ... | ... | ... | 7 |
| Parsley | ... | 1 | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | ... | ... | ... |
| Parsnip | ... | ... | ... | 0 | ... | 0 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Peas | ... | ... | ... | 0 | ... | 0 | ... | 1 | 3 | ... | ... | ... | ... | ... | ... | 1 |
| Pepper | 7 | 3 | ... | 0 | 0 | 0 | 14 | 1 | 1 | 7 | ... | ... | 0 | ... | ... | 1 |
| Potato | 7 | 7 | P | 0 | 14 | 0 | ... | 1 | 7 | ... | 1 | ... | 14 | ... | ... | ... |
| Pumpkin | ... | 0 | ... | 0 | 0 | 0 | ... | ... | 3 | ... | ... | ... | ... | ... | ... | ... |
| Radish | ... | ... | ... | 0 | ... | 0 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Rhubarb | ... | 1 | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | 14 | ... | ... |
| Rutabaga | ... | ... | ... | 0 | ... | 0 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Spinach | ... | 1 | ... | 0 | 7 | 0 | ... | 1 | 1 | 7 | ... | ... | ... | 14 | ... | ... |
| Squash, summer | 1 | 0 | ... | 0 | 0 | 0 | ... | 1 | 3 | ... | ... | ... | ... | ... | ... | ... |
| Squash, winter | ... | 0 | ... | 0 | 0 | 0 | ... | ... | 3 | ... | ... | ... | ... | ... | ... | ... |
| Sweet corn | ... | 1 | P | ... | ... | ... | ... | 1 | 1 | ... | P | P | ... | ... | ... | 3 |
| Sweet potato | P | ... | ... | 0 | 14 | 0 | ... | ... | 7 | ... | ... | ... | 14 | ... | ... | ... |
| Swiss chard | ... | 1 | ... | 0 | 7 | 0 | ... | ... | 1 | 7 | ... | ... | ... | 14 | ... | ... |
| Tomato | 1 | ... | ... | 0 | 0 | 0 | 14 | 1 | 1 | 7 | ... | ... | ... | ... | ... | 1 |
| Turnip, roots | ... | ... | ... | 0 | ... | 0 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Turnip, tops | ... | 1 | ... | 0 | 7 | 0 | ... | 1 | 1 | ... | ... | ... | ... | ... | ... | ... |

Preharvest intervals (PHIs) listed are minimums; at maximum application rates, the PHI for some products is greater than the period indicated here. Additional restrictions (limiting the total number of applications or restricting the use of treated plants for livestock feed) also may apply. S = apply to seeds or seedlings only; P = apply at or before planting or as early-season sidedress according to label; X = preharvest interval not specified; . . . = not registered for use on this crop.
*Use restricted to certified (licensed) applicators.

Visual inspection is just that—looking at plants for the presence of insects and mites. This technique is helpful in detecting non-winged aphids and spider mites. Inspect the undersides of leaves, as this is generally where aphids and spider mites are located. Again, using a 10x hand lens is usually necessary.

### Chemical Management

Pesticides (including microbial insecticides) labeled specifically for use on one or more greenhouse-grown vegetables or herbs are listed in Tables 3 and 4. Many of these pesticides have short residual activity, which means that repeated applications may be needed. Be sure to read the label carefully before making any applications; for the application to be legal, the insecticide label must list the vegetable crop on which you plan to apply it. When applying most insecticides, strive for spray coverage of upper and lower surfaces of leaves (easiest when plants are small) for maximum control.

### Biological Management

Biological control agents (natural enemies) available for purchase and release against several major insect and mite pests of greenhouse crops are listed in Table 5. These agents, along with formulations of the microbial insecticides *Bacillus thuringiensis* and *Beauveria bassiana*, may be used on or in a very wide range of

**Table 3. Insecticides and miticides labeled specifically for use on one or more greenhouse-grown vegetables (See product labels to be sure that use on any specific crop is included on the product label.)**

| Common name | Trade name | Target pests |
|---|---|---|
| azadirachtin | Azatin/Ornazin | aphids, caterpillars, fungus gnats, leafminers, shore flies, thrips, whiteflies |
| *Bacillus thuringiensis* var. *israelensis* | Gnatrol | fungus gnat larvae |
| *Bacillus thuringiensis* var. *kurstaki* | Dipel/MVP II/others | caterpillars (imported cabbageworm, diamondback moth, and cabbage looper) |
| *Beauveria bassiana* strain GHA | Botanigard | aphids, thrips, whitefies |
| bifenazate | Floramite | spider mites |
| cinnamaldehyde | Cinnamite | aphids, spider mites |
| endosulfan | Fulex Thiodan Smoke | thrips, whiteflies |
| endosulfan | Thiodan | aphids, whiteflies |
| imidacloprid | Admire, Provado, Marathon II | aphids, whiteflies |
| paraffinic oil | Ultra-Fine horticultural oil | aphids, spider mites, leafminers, thrips, whiteflies |
| potassium salts of fatty acids | insecticidal soap/M-Pede | aphids, spider mites, thrips, whiteflies |
| malathion | Malathion | aphids, cabbage loopers, spider mites, thrips, whiteflies |
| nicotine | Fulex Nicotine Smoke | aphids, thrips |
| pyrethrins plus piperonyl | Pyrethrum TR 1100 | aphids, fungus gnats (adults), spider mites, thrips, whiteflies |

**Table 4. Insecticides and miticides labeled specifically for use on one or more greenhouse-grown herbs (See product labels to be sure that use on any specific crop is included on the product label.)**

| Common name | Trade name | Target pests |
|---|---|---|
| azadirachtin | Azatin | aphids, caterpillars, fungus gnats, whiteflies, thrips, beetles |
| | Ornazin | aphids, caterpillars, thrips, fungus gnats, whiteflies, beetles |
| *Bacillus thuringiensis* var. *israelensis* | Gnatrol | fungus gnats |
| *Bacillus thuringiensis* var. *kurstaki* | Dipel | caterpillars |
| *Beauveria bassiana* | Botanigard | aphids, thrips, whiteflies, mealybugs |
| cinnamaldehyde | Cinnamite | aphids, mites |
| horticultural oil | Ultra-Fine Spray Oil | aphids, mites, thrips, whiteflies, beetles |
| insecticidal soap | Insecticidal Soap | aphids, mites, thrips, whiteflies, mealybugs |
| | M-Pede | aphids, mites, thrips, whiteflies, mealybugs |
| pyrethrin | 1100 Pyrethrum TR | aphids, caterpillars, fungus gnats, beetles, mealybugs, mites, thrips, whiteflies |
| *Steinernema feltiae* | Nemasys, Nemashield, Scanmask, and Entonem | fungus gnats |

plant species (including most vegetable crops). Some important points to remember when considering the use of parasitic or predaceous insects include:

- When using predators or parasites, it is important to avoid spraying conventional insecticides and miticides not only during the period when the natural enemies are released but beforehand as well. Residues of some insecticides may remain toxic on greenhouse surfaces for up to 2 to 3 months (though most break down much faster).
- Reduced-risk pest control materials, which include *Bacillus thuringiensis*, insecticidal soaps, horticultural oils, cinnamon oil, *Beauveria bassiana*, and azadirachtin, have less impact on natural enemies. Because these materials have short residual activity or are more pest-specific than many conventional insecticides, natural enemies can be released following use of these materials without any harmful effects.
- Predators and parasites do not eliminate pests; they reduce their densities. And predators and parasites do not reduce pest densities immediately; they take time. Pest-management programs based on the release of natural enemies are most likely to be successful in stable greenhouse systems, not in houses where transplants are produced and moved out in a short time. In short-lived transplant production houses (especially where growers produce plants for their own fields), sanitation prior to starting the transplants and effective exclusion by means of tight houses and fine screening are usually the keys to success.
- If you are using biological control organisms for the first time, be sure to seek advice from one of the authors of this chapter or another qualified Extension specialist (in addition to any advice offered by the supplier).

**Table 5. Commercially available biological control agents for release against insects and mites on greenhouse-grown vegetables (See the section "Biological Management" on page 232 regarding advice on the use of predators and parasites for insect control.)**

| Insect or mite | Biological control agent | Type |
|---|---|---|
| Aphids | *Aphelinus abdominalis* | Parasitic wasp |
| | *Aphidius colemani* | Parasitic wasp |
| | *Aphidius ervi* | Parasitic wasp |
| | *Aphidoletes aphidimyza* | Predatory midge |
| | *Chrysoperla carnea* | Predator (green lacewing) |
| | *Hippodamia convergens* | Predatory ladybird beetle |
| Fungus gnats (larvae) | *Hypoaspis miles* | Predatory mite |
| | *Steinernema feltiae* | Beneficial nematode |
| Leafminers | *Dacnusa sibirica* | Parasitic wasp |
| | *Diglyphus isaea* | Parasitic wasp |
| Spider mites | *Feltiella acarisuga* | Predatory midge |
| | *Mesoseiulus longipes* | Predatory mite |
| | *Neoseiulus californicus* | Predatory mite |
| | *Phytoseiulus persimilis* | Predatory mite |
| Thrips | *Neoseiulus (= Amblyseius) cucumeris* | Predatory mite |
| | *Neoseiulus (= Amblyseius) degenerans* | Predatory mite |
| | *Orius insidiosus* | Predatory minute pirate bug |
| Whiteflies | *Delphastus catalinae* | Predatory ladybird beetle |
| | *Encarsia formosa* | Parasitic wasp |
| | *Eretmocerus eremicus* | Parasitic wasp |

## Recommended Web Resources

**http://www.ipm.uiuc.edu/ifvn/index/html**
*Illinois Fruit and Vegetable News* is a newsletter on production and pest management.

**http://www.vegedge.umn.edu/**
*Midwest Vegetable Newsletter* and other vegetable production and pest management information are available at the University of Minnesota's "VegEdge."

**http://www.entm.purdue.edu/Entomology/ext/targets/ID/**
Click on the link here for the current *Midwest Vegetable Production Guide.*

**http://ohioline.osu.edu/b672/index.html**
This is the Web site for the *Ohio Vegetable Production Guide.*

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# Weed Control for Commercial Vegetable Crops

Weed management requires a multifaceted approach, built upon an understanding of weeds and the crop. Weed management may involve nonchemical methods, chemical methods (herbicides), or a combination of the two. Deciding which methods to use depends on environmental concerns, marketing opportunities, desired management intensity, labor availability, weed pressure, and the crop.

The first step in weed management is to identify the weeds and understand their life cycles. For assistance, consult identification guides, such as *Weeds of the North Central States* [Bulletin 772, University of Illinois Agricultural Experiment Station; available from ACES/ITCS Marketing and Distribution, 1917 S. Wright St., Champaign, IL 61820; (800)345-6087]. Weeds may be categorized by life cycles, and management strategies can be developed accordingly. Annual weeds complete their life cycles in 1 year and reproduce solely by seed. Annuals are divided into summer and winter groups depending on when they grow. Primary tillage operations often control winter annuals before a crop is planted in the spring. The most common weeds in vegetable crops are summer annuals (such as barnyardgrass, giant foxtail, common purslane, redroot pigweed, and common lambsquarters). Mechanical and cultural weed-management methods help in suppressing summer annuals. Perennial weeds live for more than 2 years and reproduce by seed or vegetative structures (stolons, rhizomes, corms, bulbs, tubers, or roots). Because perennial weeds are extremely difficult to manage in vegetable crops, it is usually better not to use a field with severe perennial weed problems.

There are three sections in this chapter: nonchemical weed-management strategies, chemical weed-management strategies, and environmental and health hazards of herbicides. Many nonchemical weed-management methods are commonsense farming practices. These practices are of increasing importance due to consumer concerns about pesticide residues, potential environmental contamination from pesticides, and unavailability of many older herbicides.

## Nonchemical Weed-Management Strategies

Weed management should start with nonchemical strategies that reduce problems caused by weeds. The aim should be to manage the weed population so that it is below a level that reduces your economic return (the economic threshold). In some instances, the cost of controlling weeds may be more than the economic return obtained from any yield increase. This situation occurs when a few weeds are present or the weeds germinate late in the season. In those instances, the best strategy may be to do nothing. In other situations, weed populations and other considerations may require combining herbicides with nonchemical approaches.

### Cultural Practices

You should aim to establish a vigorous crop that competes effectively with weeds. This approach starts with your *land selection*. A general rule is not to plant vegetables on land with a history of heavy weed infestation, especially of perennial weeds.

*Crop selection* can reduce the effects of weed competition. One criterion in selecting a crop should be the weed problems of the field. Plant the most competitive crops in the most weed-infested fields and the least

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

competitive crops in the cleanest ones. Consider planting heavily infested fields as long-term set-aside acres or as nonrow crops such as alfalfa. Permanent cover should help prevent buildup of annual weeds.

*Crop rotation* is another practice that can reduce weed problems. The characteristics of the crop, the methods used to grow it, and the herbicides used inadvertently allow certain weeds to escape control. Rotation also affects the weed-management tools at your disposal. Rotating between crops improves growth and the crops' competitiveness. Related vegetables should not be grown in the same location in successive years. Table 1 lists related vegetable crops.

Wild proso millet is an example of a problem weed for which rotation is an important management tactic. Rotating from sweet corn to small grains, early-planted peas, or alfalfa almost completely eliminates wild proso millet. Alfalfa, early-planted peas, and small grains are established before the soil is warm enough for wild proso millet to germinate. Rotating from sweet corn to broadleaf crops allows use of post-emergence grass herbicides to manage wild proso millet.

Once a crop is selected, use *adaptive, vigorous varieties* resistant to diseases. Disease-infested plants cannot effectively compete with weeds.

*Narrower row spacings and proper plant densities* assure that the crop rapidly closes canopy. A closed canopy shades out later-emerging weeds and prevents germination of weed seeds requiring light. Weeds seldom are a problem once canopy closure occurs. Proper row spacing and plant density also allow row cultivation.

Another cultural method to improve crop competitiveness is to use the *correct planting time.* Crops may be divided into warm- and cool-season plants, depending on the optimal temperature for their growth. The planting date affects the time to emergence and early seedling vigor of the crop, which are important in determining crop competitiveness. Cool-season crops germinate at cooler soil temperatures and thus compete better against early-emerging weeds than do warm-season crops. Table 2 lists crops according to their adaptation to field temperatures. Time plantings so that temperatures are favorable for crop growth.

*Adequate fertilization and appropriate insect and disease management* are important in assuring a competitive crop. Adequate fertility assures rapid, uniform germination and good crop growth, which enhance the crop's competitive ability. For information on fertility, consult *Midwestern Vegetable Production Guide for Commercial Growers* (Circular 1361, University of Illinois Extension; available from ACES/ITCS Marketing and Distribution). Disease-management information is contained in Chapter 9 ("Plant Disease Management for Commercial Vegetable Crops") of this handbook and insect-management information in Chapter 7 ("Insect Pest Management for Commercial Vegetable Crops"). While poor insect and disease control reduce a crop's competitiveness, inadequate weed control can also cause insect and disease problems.

*Mulching* can be useful in managing weeds. Mulches may be classified as either natural (straw, leaves, paper, and compost) or synthetic (plastic). Because natural mulches are difficult to apply over large areas, they are best for small, specialized areas. Natural mulches should be spread evenly at least 1½ inches thick over the soil to prevent light penetration. Natural mulch materials must be free of weed seeds and other pest organisms and be heavy enough that they are not easily displaced by wind or water. A major advantage of natural mulches is that they add organic matter to the soil.

**Table 1. Botanically related vegetables**

| **Corn** | **Cucurbits** | **Onions** |
|---|---|---|
| Dent corn | Muskmelon | Garlic |
| Popcorn | Pumpkin | Onion |
| Sweet corn | Summer squash | |
| | Watermelon | **Solanaceous** |
| **Crucifers** | Winter squash | Pepper |
| Brussels sprout | | Potato |
| Cabbage | **Legumes** | Tomato |
| Cauliflower | Dry bean | |
| Horseradish | Lima bean | **Spinach** |
| Kale | Pea | Beets |
| Radish | Snap bean | Chard |
| Rutabaga | Soybean | Spinach |

**Table 2. Classification of vegetable crops according to their adaptive field temperatures**

| Cool-season | | Warm-season | |
|---|---|---|---|
| Hardy* | Semihardy | Tender | Very tender |
| Asparagus | Carrot | Pepper | Cucumber |
| Broccoli | Cauliflower | Snap bean | Eggplant |
| Cabbage | Chinese | Sweet corn | Lima bean |
| Horseradish | cabbage | | Muskmelon |
| Onion | Lettuce | | Okra |
| Pea | Potato | | Pumpkin |
| Spinach | | | Squash |
| | | | Watermelon |

*Hardy crops are most tolerant of cool temperatures and frost, while very tender crops are most susceptible to frost and cool temperatures.

Synthetic mulches control weeds within the row, conserve moisture, increase soil temperature, and are easy to apply. Black plastic mulches are the most common and are particularly effective in improving early-season growth of warm-season crops such as tomatoes, muskmelons, watermelons, and peppers. Better early-season growth of these crops improves their competitive ability against weeds. Plastic mulches used in combination with trickle irrigation also improve water-use efficiency.

The biggest disadvantage of plastic mulch is disposal, as many landfills do not accept it. Photodegradable plastic mulches have been developed, but their season-long persistence has been a problem. Also, photodegradable mulches just degrade into smaller pieces of plastic that still contaminate the environment. Biodegradable plastic mulches are not yet widely available.

### Mechanical Practices

Mechanical weed management relies on primary and secondary tillage implements such as the rotary hoe and the row cultivator. Mechanical weed management starts with seedbed preparation. Few reduced-till systems have been developed for vegetable crops. Reduced-till suggestions are included in the section on chemical weed-management strategies in this chapter.

*Moldboard plowing* is usually the first step in mechanically managing weeds. It is particularly useful in controlling emerged annual weeds. An important second step is often *rotary hoeing* for mechanically managing weeds in large-seeded vegetable crops (sweet corn, snap beans, lima beans, and peas). Rotary hoeing needs to be done after the weeds germinate but before they emerge. It does not control large-seeded weeds, such as velvetleaf and shattercane.

Once the crop has emerged or transplants are established, a *row cultivator* may be used to manage emerged weeds. Adjust the cultivator sweeps or teeth to dislodge or cover as many weed seedlings as possible. Seedling weeds can be killed by cultivating 1 to 2 inches deep. The best weed control is obtained with a row cultivator in relatively dry soils by throwing soil into the crop row to cover small weed seedlings. Avoid crop injury from poor cultivation, which reduces crop yields.

In some vegetable crops, such as asparagus, *mowing* can be an effective weed-management tool. Mowing can prevent the production of weed seeds and kill upright weeds, reducing competition. Mowing must be carefully timed to prevent the growth of biennial weeds when reducing competition from upright plants. Timely, repeated mowing also helps deplete the food reserves of perennial weeds.

Mechanical control has many limitations that must be considered when designing weed-management systems. Because mechanical management relies on relatively dry weather, a rainy period may eliminate mechanical management options and lead to severe weed competition. Relying entirely on mechanical practices to manage weeds is difficult on large acreages. Also, several weeds are extremely difficult to manage unless herbicides are combined with nonchemical approaches. The problem weeds include wild proso millet in sweet corn, as well as Canada thistle, hemp dogbane, field bindweed, quackgrass, and johnsongrass. Newly introduced problem weeds often show up in scattered patches along headlands and field borders. These probably are best controlled or eradicated with herbicides before large areas are infested.

### Biological Practices

Currently, no system using insects or diseases to control weeds common to vegetable crops exists in the Midwest. Most biological management systems using diseases or insects to control problem weeds have centered on western rangeland areas. One biological system that has potential in the Midwest is the use of cover crops to suppress the development of weeds. These systems are still experimental, and problems have been encountered, including the duration of weed control from cover crops and the spectrum of weeds controlled. Herbicides are often required to kill the cover crop and to manage any emerged weeds. Overall, cover-crop systems tend to control small-seeded annual broadleaf weeds the best. The most promising cover-crop system is winter rye. Winter rye is planted in the late summer or early fall; the rye is killed in the spring with Roundup Ultra Max, and the crop is no-till planted. The system is experimental and should be evaluated in small areas before being used extensively.

Table 3 summarizes some of the nonchemical weed-management practices. An integrated approach should be used that combines many different practices to manage weeds. This approach must be adaptive, aiming to prevent weed problems or cope with any that occur.

## Chemical Weed-Management Strategies

Several herbicides are often labeled for a crop. Scouting your area to determine which weeds are present can allow you to select the herbicide that can give you the best control. Potential environmental hazards

**Table 3. Nonchemical weed-management practices**

| Practice | Comments |
|---|---|
| **Cultural** | |
| 1. Land selection | Avoid fields with a history of weed problems. |
| 2. Crop selection | Grow the most competitive crops in fields with a history of weed problems. |
| 3. Crop rotation | Rotate between vegetables and nonrow crops such as alfalfa. Rotate between vegetables in different botanical categories. |
| 4. Adapted crop varieties | Select crop varieties adapted for your area. |
| 5. Proper row spacings and plant densities | Use row spacings and plant densities that assure rapid crop-canopy closure. |
| 6. Correct planting times | Plant crops when soil temperatures favor rapid germination and emergence. |
| 7. Appropriate fertility, disease, and insect management | Vigorous, healthy crops are more competitive against weeds. |
| 8. Mulch | Natural mulches are difficult to use over large acreages. Synthetic (plastic) mulches are useful to manage weeds within the row in warm-season crops. Consider disposal problems when using plastic mulches. |
| **Mechanical** | |
| 1. Moldboard plowing | Can eliminate emerged annual weeds. |
| 2. Rotary hoeing | Useful to manage small-seeded weeds in large-seeded crops such as sweet corn, snap beans, lima beans, and peas. |
| 3. Row cultivating | Dislodge or cover as many weed seedlings as possible. Avoid damaging crop root systems. |
| 4. Mowing | Mow weeds as soon as flowers appear so no viable weed seed is produced. |
| **Biological** | |
| 1. Cover crops | Still experimental. Winter rye system is the most promising and most effective against small-seeded broadleaf weeds. |
| 2. Insect or disease pests of weeds | No current system uses insects or diseases to manage weeds common to vegetables. |

must be considered when selecting a herbicide. Herbicide labels contain information on these hazards. The last section of this chapter discusses potential environmental hazards.

All the herbicides labeled for a crop are not necessarily listed in Table 4. If you are unfamiliar with a herbicide, conduct a small test under your environmental conditions and cultural practices before using the herbicide extensively.

### Always Read and Understand the Herbicide Label Before Use

Reading the herbicide label is a very profitable use of your time. Label information directs you to correct uses, application methods, rates, and potential environmental hazards. Follow label directions for the best possible control with minimal crop injury and environmental contamination. The label contains restrictions on use and discusses environmental and soil conditions that can affect crop injury, influence the effectiveness of weed control, and cause nontarget site effects.

### Use a Herbicide That Is Labeled for Your Particular Use and Crop

Using a nonregistered pesticide can cause harmful residues in the vegetable crop, which can result in crop seizure and consumer injury. The label also states whether the herbicide is a restricted use or general use pesticide. Labels for restricted use pesticides contain a statement that the products are restricted and that only licensed applicators may buy them and supervise their application.

The information in this chapter is current as of the date of publication. Watch for notices of changes in the U.S. Environmental Protection Agency (USEPA) registration of herbicides in the *Pest Management and Crop Development Bulletin* (available from University of Illinois Extension Newsletter Service, 528 Bevier Hall, 905 S. Goodwin Ave., Urbana, IL 61801, (800)348-6087; also available free on the Web at http://www.ipm.uiuc.edu/bulletin/index.php). Mail subscriptions are $50. Or look for notices in the *Illinois Fruit and Vegetable News* (available from Rick Weinzierl, Department of Crop Sciences, AW-101 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801).

### Reduced-Tillage Systems

Reduced-tillage systems are a method to combat soil erosion. Roundup Ultra Max, Gramoxone Max, or Touchdown may be applied outside the normal growing season to control emerged weeds in reduced-tillage systems. Weeds should be growing actively, and the application must be made before the crop has emerged. If you are applying Roundup Ultra Max to control perennial weeds, it is recommended that it be applied before disturbing the soil. After Roundup Ultra Max is applied, it must be allowed to translocate throughout the perennial weed for several days, or incomplete control may result. Follow Roundup Ultra Max label directions carefully for the rates and timing of application. If perennial weeds are not a major problem, you can eliminate early flushes of weeds by applying Roundup Ultra Max or Gramoxone Max to all weeds that emerge. Plant the crop with minimal working of the soil. Never apply Roundup Ultra Max or Gramoxone Max to an emerged crop because severe crop injury or death will occur.

Roundup Ultra Max and Gramoxone Max control most annual broadleaf and grass weeds. Neither herbicide has any soil-residual activity, so other weed-control measures are necessary during the growing season. Gramoxone Max also suppresses perennials by killing their shoots but should not be expected to control regrowth of perennial weeds from rhizomes or other underground storage organs. Roundup Ultra Max is better for controlling perennials because it kills shoots and translocates to destroy underground parts. Roundup Ultra Max only suppresses some particularly hard-to-control perennials, such as bindweed, hemp dogbane, and milkweed. To obtain control of these perennials, applications of high rates, repeat applications of Roundup Ultra Max (within label guidelines), or mechanical removal may be necessary.

### How to Use Herbicide Tables

Use Table 4 to determine the herbicides that are labeled for use in your crop. Once you have determined the herbicides available for your crop, use Table 5 to determine which of the labeled herbicides provides control of the weeds you have present. If you are uncertain of the herbicide name, you can find both common and trade names of all herbicides in this chapter in Table 6. These tables are not intended to replace careful reading of a current herbicide label. **Always read the label before applying any pesticide.**

### Herbicide Rates and Guidelines for Use in Vegetable Crops

All herbicide rates given in Table 4 are in rate of product per broadcast acre. Adjust amounts accordingly for banded applications. Make preemergence applications before weeds emerge or after removing any weeds present. Make postemergence applications after weeds have emerged. Make stale seedbed treatments only if weeds have emerged but no crop plants are present.

*(Text continues on page 261.)*

**Table 4. Herbicide rates and guidelines for use in vegetable crops**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **ASPARAGUS** | | |
| **Preemergence** | | |
| Devrinol (napropamide) | 4 to 8 lb of 50DF | Rainfall or irrigation is necessary for activity. Established beds only. |
| Karmex, others (diuron) | 2 to 4 lb of 80DF | Do not apply to young plants during the first year. Two applications per year may be made. See label restrictions. |
| Sencor (metribuzin) | 1 to 2 qt of 4L or 4F | Established beds only. |
| Sinbar (terbacil) | 1.5 to 3 lb of 80WP | With direct-seeded asparagus, spray activated carbon over rows. High-organic soils inactivate Sinbar. Do not use on soils with less than 1% organic matter. |
| Spartan (sulfentrazone) | 6.7 oz of 75DF | Apply to establish crop in spring prior to spear emergence. Rainfall or irrigation needed to move into soil. Maximum one application per year. |
| Solicam (norflurazon) | 2.5 to 5 lb of 80DF | Apply in the fall after chopping ferns or in the spring before emergence. One application per year. |
| Treflan, others (trifluralin) | 1 to 4 pt of HFP | See label for incorporation instructions. Established beds only. |
| **Postemergence** | | |
| 2,4-D amine | See label. | Apply to actively growing weeds. |
| Clarity, Banvel (dicamba) | 0.5 to 1 pt | Apply to actively growing weeds immediately after harvest. Discard crooked spears. May cause injury to susceptible plants. |
| Fusilade DX (fluazifop-butyl) | 2 to 3 pt | Use oil concentrate or nonionic surfactant. Apply to nonbearing asparagus only. |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use a crop-oil concentrate. |
| Sandea (halosulfuron) | 0.5 to 1 oz/A | Apply to established asparagus bed or 6 weeks after transplanting. Make a maximum of two applications per crop cycle. |
| Stringer (clopyralid) | ⅓ to ⅔ pt of 3EC | Do not use on harvested spears. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. Apply at least 1 week before spears emerge or delay until after harvest. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **CARROTS** | | |
| **Preemergence** | | |
| Treflan, others (trifluralin) | 1 to 2 pt of HFP | Must be incorporated. |
| **Postemergence** | | |
| Fusilade DX (fluazifop-butyl) | 2 to 3 pt | Use crop-oil concentrate or nonionic surfactant. Two applications per year may be made. |
| Lorox (linuron) | 1 to 2 lb | Apply when crop is at least 3 inches tall. Do not use if temperature is above 85°F. |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate. |
| Sencor (metribuzin) | 0.33 lb of 75DF or 0.5 pt of 4L | See label warnings. Carrots must have at least 5 or 6 leaves. Weeds must be small. |
| Select (clethodim) | 0.5 pt | Use crop-oil concentrate. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **COLE CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, AND TURNIP)** | | |
| **Preemergence** | | |
| Command (clomazone) | 0.7 to 1.3 pt of 3ME | Cabbage only. Apply before transplanting. May cause early-season stunting or discoloration of cabbage. |
| Dacthal (DCPA) | 6 to 14 lb of 75WP | Activity is improved by shallow incorporation or irrigation after application. |
| Devrinol (napropamide) | 2 to 4 lb of 50DF | May apply to transplants or direct-seeded plants. Incorporate shallowly. |
| Goal (oxyfluorfen) | 1.25 to 2.5 pt of 1.6EC | Apply to soil after final tillage but before transplanting. May cause foliar injury. Do not apply to Brussels sprout. |
| Prefar (bensulide) | 5 to 6 qt of 4EC | Incorporate shallowly. |
| Spartan (sulfentracone) | 2.25 to 12 oz | Processing cabbage only, transplanted or direct-seeded cabbage only. |
| Treflan, others (trifluralin) | 1 to 1.5 pt (direct-seeded) or 1 to 2 pt (transplanted) of HFP | Direct-seeded cole crops exhibit marginal tolerance to Treflan. Stunting can occur under stress. Must be incorporated. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **COLE CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, AND TURNIP) (CONT.)** | | |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 30-day preharvest interval. |
| Stinger (clopyralid) | 4 to 8 fl oz | Emerged broadleafs, primarily composites; 2 applications maximum per year. 30-day preharvest interval. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 2 to 3 qt | See discussion of reduced-tillage systems. |
| **CORN (POP)** | | |
| **Preemergence** | | |
| AAtrex, others (atrazine) | 3.2 to 4 pt of 4L or 1.8 to 2.2 lb of Nine-O | Restricted use pesticide. Weed resistance to atrazine is a problem. Atrazine can contaminate surface water and groundwater. Atrazine carryover can injure follow crops. |
| Balance (isoxaflutole) | 1.25 to 3 oz of WDG or 1.5 to 4.5 fl oz of SC | |
| Dual Magnum, others (*S*-metolachlor) | 1 to 2 pt of 7.6EC | |
| Eradicane (EPTC + safener) | 4.75 to 7.33 pt of 6.7EC | Must be incorporated. Can help with perennial grass control; see label. |
| Harness, DoublePlay, TopNotch (acetolachlor) | 1.25 to 2.75 pt of Harness 7EC, or 4.5 to 7 pt of DoublePlay, or 4 to 6 pt of TopNotch | |
| Lasso, others (alachlor) | 2 to 4 qt of 4EC | |
| Outlook (dimethenamid-P) | 12 to 21 fl oz of 6EC | |
| Sutan+ (butylate + safener) | 2.5 to 3.5 qt of 6.7EC | Especially useful on sandy soils. Must be incorporated. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **CORN (POP) (CONT.)** | | |
| **Postemergence** | | |
| 2,4-D amine (numerous trade names) | See label. | Apply to actively growing broadleaf weeds, preferably before corn is 8 inches tall, or use drop nozzles. Do not treat corn in the tassel to dough stage. May cause stalk to become brittle. |
| AAtrex, others (atrazine) | 1 to 1.5 pt of 4L or 1.6 lb of Nine-O | Applied with crop oils. See label precautions. Do not use after June 10. |
| Accent (nicosulfuron) | 0.66 oz of 75DF | Avoid using with some soil insecticides, such as Counter. Check with popcorn company to determine variety tolerance. Do not apply to popcorn taller than 20 inches (6 or fewer collars). |
| Aim (carfentrazone) | 0.33 oz of 40WG | Use in a tank mix with other post herbicides. |
| Banvel and Clarity (dicamba) | 0.5 to 1 pt of Banvel or 16 fl oz of Clarity | **Can injure sensitive crops.** Verify that popcorn variety is tolerant before using. Apply to popcorn between emergence and 8 inches tall (5-leaf stage). |
| Basagran (bentazon) | 1.5 to 2 pt of 4S | Apply when weeds are small and actively growing. Use crop-oil concentrate. |
| Beacon (primisulfuron) | 0.76 oz of 74WD | Only make semidirected or directed applications with drop nozzles when popcorn is between 10 and 48 inches tall and before tassel emergence. Test varieties for sensitivity to Beacon before using. |
| Buctril (bromoxynil) | 1 to 1.5 pt of 2EC | Primarily a contact herbicide, so thorough coverage is essential for control. Can cause temporary leaf burn of popcorn. |
| Callisto (mesotrone) | 3 oz | Yellow popcorn only. Use crop-oil concentrate only. Add atrazine. |
| Distinct (diflufenzopyr + dicamba) | 4 to 6 oz | Do not apply to corn more than 36 inches tall. Use nonionic surfactant plus UAN. |
| Permit (halosulfuron) | 0.67 oz of 75WSG | Apply as broadcast or directed spray from spike to layby. Include 0.5% nonionic surfactant. Controls nutsedge. |
| Resource (flumiclorac) | 4 to 8 fl oz | Do not apply under stress conditions. |
| Stringer (clopyralid) | ⅓ to ⅔ pt | Do not apply to popcorn over 24 inches tall. Can make two applications 21 days apart. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | Restricted use pesticide. See discussion of reduced-tillage systems. Can also be used as a harvest aid. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **CORN (POP)** | | |
| **Stale seedbed (cont.)** | | |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 2 pt | See discussion of reduced-tillage systems. |
| **CORN (SWEET)** | | |
| **Preemergence** | | |
| AAtrex, others (atrazine) | 3.2 to 4 pt of 4L or 1.8 to 2.2 lb of Nine-O | Restricted use pesticide. Can contaminate surface water and groundwater. Weed resistance is a problem. Can injure follow crops. |
| Dual Magnum (S-metolachlor) or Dual Magnum II | 1 to 2 pt of 7.6EC | May be incorporated or applied before emergence. |
| Eradicane Extra (EPTC + safener + extender) | 4 to 8 pt of 6.7EC | Suppresses wild proso millet. Must be incorporated. Contains an extender that may lengthen the period of control. |
| Lasso, others (alachlor) | 2 to 4 qt of 4EC | Restricted use pesticide. |
| Outlook (dimethenamid) | 12 to 21 fl oz of 6EC | |
| Prowl (pendimethalin) | 1.2 to 3.6 pt of 3.3EC | Do not incorporate. For use on processing varieties. Do not apply prior to planting. |
| Sutan+ (butylate + safener) | 2.5 to 3.5 qt of 6.7EC | Especially useful on sandy soils. Must be incorporated. |
| **Postemergence** | | |
| 2,4-D amine | See label. | Apply to actively growing weeds, preferably before corn is 6 inches tall. See label restrictions. Sweet corn injury may occur. |
| Aim (carfentrazone-ethyl) | EW at 0.5 fl oz or 40DG at 0.33 oz | To reduce injury, use drop nozzle or direct sprayers. |
| AAtrex, others (atrazine) | 1 to 1.5 pt of 4L, or 1.8 lb of 80WP, or 1.6 lb of Nine-O | May be applied with crop oils. See label precautions. Do not use after June 10. |
| Accent (nicosulfuron) | 0.67 oz of 75SP | Processing corn only. Use only on tolerant varieties listed on label. |
| Basagran 4S (bentazon) | 1.5 to 2 pt | Apply when weeds are small and actively growing. Consult label for specific directions. |
| Permit (halosulfuron) | 0.66 oz | Apply from spike to layby. Do not use on stressed corn or on Jubilee. Some varieties may be severely injured. Do not use on corn treated with soil-applied organophosphate insectides. |
| Stringer (clopyralid) | ⅓ to ⅔ pt | Do not apply to sweet corn taller than 18 inches. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.3 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max,Touchdown, others (glyphosate) | 1.5 to 2 pt | See discussion of reduced-tillage systems. |
| **CUCURBITS (CUCUMBER, MUSKMELON, AND WATERMELON)** | | |
| **Preemergence** | | |
| Alanap (naptalam) | 6 to 8 qt of 2L | A second application may be made before vining. Usually tank-mixed with Prefar. |
| Command (clomazone) | 0.4 to 2 pt of 3ME | Do not use on jack-o-lantern pumpkins. |
| Curbit (ethalfluralin) | 3 to 4.5 pt of 3EC | Read label carefully before using. Avoid using on cool, wet soils. Requires signing a waiver of liability before using. |
| Prefar (bensulide) | 5 to 6 qt of 4EC | Incorporate or irrigate in. May be tank-mixed with Alanap. Do not plant other than label-specified crops for 18 months after application. |
| Sandea (halosulfuron) | 0.5 to 1 oz | Apply after seeding but before cracking. Apply before transplanting. |
| Treflan, others (trifluralin) | 1 to 2 pt of HFP | Apply after establishment to melons that have 3 to 4 true leaves. Direct between rows and incorporate. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Poast (sethoxydim) | 1.0 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 14-day preharvest interval. |
| Sandea (halosulfuron) | 0.5 to 1 oz | Some injury might occur. |
| Select (clethodim) | 0.5 pt of 2EC | Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 0.8 to 8 pt | See discussion of reduced-tillage systems. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **DRY BEANS (WHITE, NAVY, KIDNEY, PINTO, LIMA, AND ADZUKI)** | | |
| **Preemergence** | | |
| Dual Magnum (S-metolachlor) or Dual II Magnum | 1 to 2 pt of 7.6EC | |
| Eptam (EPTC) | 2.5 to 3.5 pt of 7EC | Do not use on adzuki beans, cowpeas, lima beans, or other flat-pod beans. Incorporate immediately. |
| Lasso, others (alachlor) | 2.5 to 3 qt of 4EC or MT | Use on lima and red kidney beans only. |
| Outlook (dimethenamid-P) | 10 to 21 fl oz | Apply ppi, pre, or after planting when beans have 1 to 3 trifoliate leaves. Do not use on lima beans. |
| Prowl (pendimethalin) | 1.2 to 3.6 pt of 3.3EC | Must be incorporated. |
| Pursuit (imazethapyr) | 3 fl oz of 2EC | Use on lima and red kidney beans only. |
| Sandea (halosulfuron) | ½ to ⅔ oz | Apply after seeding but prior to cracking. |
| Spartan (sulfentrazone) | 1.5 to 5.3 oz of 75DF | Rainfall or irrigation needed to move into soil. |
| Treflan, others (trifluralin) | 1 to 2 pt of HFP | Must be incorporated. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Assure II (quizalofop) | 6 to 10 fl oz of 0.88EC | Use crop-oil concentrate, 1 qt per acre. Good on quackgrass. 30-day preharvest interval. |
| Basagran (bentazon) | 1 to 2 pt of 4S | Apply when weeds are small. Beans are tolerant after the first trifoliate leaf has expanded. Avoid applying when day temperatures are below 75°F. |
| Poast 1.5E (sethoxydim) | 1 to 2 pt | Use crop-oil concentrate, 2 pt per acre. Maximum of 4 pt Poast per acre per season. 30-day preharvest interval. |
| Pursuit (imazethapyr) | 3 oz of 2 L or 1.08 oz of DG | Apply after first trifoliate. Add an adjuvant. |
| Raptor (imazamox) | 4 oz | Apply when beans are in first- to third-trifoliate leaf stage. Weeds must be actively growing. Include nonionic surfactant.<br>**Fresh lima beans:** Tank-mix with Basagran to minimize lima bean response. Apply when lima beans are in first- to second-trifoliate leaf stage. |
| Sandea (halosulfuron) | 0.5 to 0.67 oz | Add ½ to 1 pt nonionic surfactant and not recommended for use under cool temperatures. (Dry bean and lima bean only.) |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **DRY BEANS (WHITE, NAVY, KIDNEY, PINTO, LIMA, AND ADZUKI) (CONT.)** | | |
| **Postemergence (cont.)** | | |
| Select (clethodim) | 6 to 8 fl oz | Include a crop-oil concentrate. Apply to actively growing grass. |
| **Stale seedbed** | | |
| Gramoxone Max | 1.3 to 2.7 pt of 3L | See discussion of reduced-tillage systems. Use on lima beans only. Also can be used as a harvest aid on dry beans. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **EGGPLANT** | | |
| **Preemergence** | | |
| Dacthal (DCPA) | 6 to 14 lb of 75WP | Apply 4 to 6 weeks after transplanting. Shallow incorporation or irrigation improves activity. |
| Devrinol (napropamide) | 2 to 4 lb of 50DF | Transplants only. |
| Prefar (bensulide) | 5 to 6 qt | Apply before planting and incorporate 1 to 2 inches. |
| Sandea (halosulfuron) | 0.5 to 1 oz | Use between row middles. Do not contact planted crop. Keep application off plastic mulch. |
| Trilin (trifluralin) | 1 to 1.5 pt of HFP | Transplants only. Requires signing a liability waiver before using. |
| **Postemergence** | | |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. |
| Select (clethodim) | 0.5 pt | Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **GREENS (CHICORY, COLLARD, KALE, MUSTARD, SPINACH, TURNIP)** | | |
| **Preemergence** | | |
| Dacthal (DCPA) | 6 to 14 lb of 75WP | Use on collard greens, kale, mustard greens, and turnip greens. Shallow incorporation or irrigation improves activity. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **GREENS (CHICORY, COLLARD, KALE, MUSTARD, SPINACH, TURNIP)** | | |
| **Preemergence (cont.)** | | |
| Prefar (bensulide) | 5 to 6 qt of 4EC | Lightly incorporate. Not for turnip greens. |
| Treflan, others (trifluralin) | 1 to 1.5 pt of HFP | Incorporate. Not for turnip greens. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. 30-day preharvest interval for all except spinach, which requires a 15-day preharvest interval. |
| Stringer (clopyralid) | ½ pt | Use on spinach, turnip greens, and roots. Do not apply within 15 days (greens) or 30 days (roots) of harvest. |
| Select (clethodim) | 6 to 8 fl oz | Include a crop-oil concentrate. Apply to actively growing grass. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | Collards only. See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **HORSERADISH** | | |
| **Preemergence** | | |
| Dacthal (DCPA) | 6 to 14 lb of 75WP | Shallow incorporation or irrigation improves activity. |
| Dual magnum (*S*-metolachlor) | 1 to 2 pt | May cause crop injury. 24c label for Illinois only. |
| Goal (oxyfluorfen) | 2.5 pt of 1.6EC | Apply after planting and before emergence. Some crop injury may occur. |
| Outlook (dimethenamid-P) | 12 to 21 fl oz | Apply from 2-leaf stage to 8-leaf stage of horseradish. Cold, wet conditions at application may cause horseradish stunting. Will not control emerged weeds. |
| Spartan (sulfentrazone) | 1.5 to 6.3 oz, depending on soil type | Apply after planting. Do not incorporate. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **HORSERADISH (CONT.)** | | |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. |
| Select (clethodim) | 0.5 pt | Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate. |
| **Stale seedbed** | | |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **LETTUCE** | | |
| **Preemergence** | | |
| Balan (benefin) | 2 to 2.5 lb of 60DF | Direct-seeded lettuce only. Must be incorporated. |
| Kerb (pronamide) | 2 to 4 lb of 50WP | Moisture is necessary to activate. Label rates vary depending on variety. |
| Prefar (bensulide) | 5 to 6 qt of 4EC | May be applied to head and leaf lettuce. Must be incorporated. |
| **Postemergence** | | |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. Preharvest intervals are 15 days for leaf and 30 days for head lettuce. |
| Select (clethodim) | 6 to 8 fl oz | Include a crop-oil concentrate. Apply to actively growing grass. Leaf lettuce only. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **OKRA** | | |
| **Preemergence** | | |
| Treflan, others (trifluralin) | 1 to 2 pt of HFP | Must be incorporated immediately after application. |
| **Stale seedbed** | | |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **ONION** | | |
| **Preemergence** | | |
| Dacthal (DCPA) | 6 to 14 lb of 75WP | Can apply at seeding or transplanting or at layby. Irrigation after application improves activity. |
| Outlook (dimethenamid-P) | 12 to 21 fl oz | Apply after dry bulb onions have reached 2 true leaves. Will not control emerged weeds. |
| Prefar (bensulide) | 5 to 6 qt of 4EC | Dry bulb onions only. Incorporate or irrigate in. |
| Prowl (pendimethalin) | 0.6 to 2.4 qt of 3.3EC | Apply when direct-seeded onions have 2 to 9 leaves or after transplanting. |
| **Postemergence** | | |
| Buctril (bromoxynil) | 1 to 1.5 pt of 2EC | Apply 2 to 3 days before onions emerge or when they have 2 to 5 true leaves. Sensitivity of onions is affected by variety and environment. |
| Fusilade DX (fluazifop-P-butyl) | 1.25 to 1.5 pt of 1EC | Use nonionic surfactant, 1 pt per acre. 45-day pre-harvest interval. Use only on dry bulb onions. |
| Goal (oxyfluorfen) | 5 to 10 fl oz of 1.6EC | Do not apply until onions have 2 true leaves. Best control is achieved when weeds are in the 2- to 4-leaf stage. Do not apply more than 2.5 pt per broadcast acre in one season. Use only on dry bulb onions. |
| Poast (sethoxydim) | 1 to 1.5 pt | Add 2 pt crop-oil concentrate per acre. 30-day pre-harvest interval. May be used on dry bulb onions, green bunching onions, garlic, and leeks. |
| Select (clethodim) | 6 to 16 fl oz | Apply to actively growing grasses. Include 1% crop-oil concentrate. |
| **Stale seedbed** | | |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **PEAS** | | |
| **Preemergence** | | |
| Dual Magnum (*S*-metolachlor) | 1 to 2 pt of 7.6EC | Apply preemergence. See label for restrictions. |
| Command (clomazone) | 1 pt of 3ME | |
| Prowl (pendimethalin) | 1.2 to 3.6 pt | Incorporate. |
| Pursuit (imazethapyr) | 3 fl oz of 2EC | Do not use if applying Treflan to peas. |
| Treflan, others (trifluralin) | 1 to 1.5 pt of HFP | Must be incorporated. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **PEAS (CONT.)** | | |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Assure II (quizalofop) | 6 to 12 fl oz of 0.88EC | Use crop-oil concentrate, 2 pt per acre. Good on quackgrass. 30-day preharvest interval. |
| Basagran (bentazon) | 1.5 to 2 pt of 4S | Apply when weeds are small. Pea injury can occur. See label precautions. Do not add crop oil. |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. |
| Pursuit (imazethapyr) | 3 fl oz of 2EC | Add nonionic surfactant. Crops must have at least 1 true leaf, or crop injury may result. Do not apply if Treflan is used. |
| Raptor (imazamox) | 3 oz | Apply to English peas at least 3 inches in height and before 5 nodes. May injure peas. Do not use if trifluralin applied ppi. If nitrogen fertilizer used, then tank-mix with Basagran to reduce pea injury. |
| Thistrol (MCPB) | 2 to 4 pt of 2EC | Apply when peas have developed 6 to 12 nodes and weeds are less than 3 inches tall. Use for Canada thistle control. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **PEPPER** | | |
| **Preemergence** | | |
| Command (clomazone) | 0.5 to 2 pt of 3ME | Use lower rates on light soil textures. Varieties differ in tolerance. Do not use on banana peppers. |
| Devrinol (napropamide) | 2 to 4 lb of 50DF | May be applied to direct-seeded plants or transplants. Incorporate. |
| Prefar (bensulide) | 5 to 6 qt of 4EC | Lightly incorporate. |
| Treflan, others (trifluralin) | 1 to 2 pt of HFP | Incorporate. Apply to transplants only. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **PEPPER** | | |
| **Postemergence (cont.)** | | |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. Maximum of 4.5 pt Poast per acre per season. 20-day preharvest interval. |
| Sandea (halosulfuron) | 0.5 to 1 oz | Apply between rows. Do not contact crop plants. Do not apply over plastic mulch. |
| Select (clethodim) | 0.5 pt | Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. Can also be used as a harvest aid. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **POTATO** | | |
| **Preemergence** | | |
| Dual Magnum (*S*-metolachlor) or Dual II Magnum | 1 to 2 pt of 7.6EC | Apply preemerge, incorporated, or at layby. Do not use on muck soils. |
| Eptam (EPTC) | 3.5 to 7 pt of 7EC | Incorporate immediately after applying. The variety Superior is sensitive. |
| Sencor (metribuzin) | 0.6 to 1.33 lb of 75DF | Make a single application before emergence. |
| Linex or Lorox (linuron) | 1.5 to 2.5 pt of 4L, or 1 to 4 lb of 50WP or 50DF | Apply after planting but before potato emergence. Plant "seed" 2 inches deep. |
| Matrix (rimsulfuron) | 1 to 1.5 oz of 25DF | Apply after hilling or drag-off, and before potatoes and weeds emerge. |
| Outlook (dimethenamid-P) | 12 to 21 fl oz | Apply following planting or after drag-off. Cold, wet conditions at application may cause potato stunting. Will not control emerged weeds. |
| Prowl (pendimethalin) | 1.2 to 3.6 pt of 3.3EC | Incorporate lightly. Do not use on muck soils. |
| Treflan, others (trifluralin) | 1 to 2 pt of HFP | Apply after planting and incorporate uniformly. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **POTATO** | | |
| **Postemergence (cont.)** | | |
| Sencor (metribuzin) | 0.5 to 1 pt of 4L, or 0.3 to 0.67 lb of 75DF | Do not use on smooth-skinned white or red-skinned potatoes. Apply only after 3 successive days of sunny weather. Apply before weeds are 1 inch tall. |
| Matrix (rimsulfuron) | 1 to 1.5 oz of 25DF | Apply before potatoes are 14 inches tall. Spray only after 3 days of sunny weather. May injure potatoes. |
| Poast (sethoxydim) | 1 to 2.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. Maximum of 5 pt Poast per acre per season. 30-day preharvest interval. |
| Select (clethodim) | 0.5 pt | Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. Can also be used as a harvest aid. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **PUMPKIN AND SQUASH** | | |
| **Preemergence** | | |
| Command (clomazone) | 1.5 to 2 pt of 3ME | Processing pumpkins and squash only. Do not use on jack-o-lantern pumpkins. |
| Curbit (ethalfluralin) | 3 to 4.5 pt of 3EC | Apply after seeding squash or pumpkins and before weed or crop emergence. Carefully read label before using. Requires signing a liability waiver. |
| Prefar (bensulide) | 5 to 6 qt of 4EC | Incorporate or irrigate in. See label restrictions. |
| Sandea (halosulfuron) | 0.5 to 1 oz | Preemergence application is safer than postemergence. |
| Treflan and others (trifluralin) | 1 to 2 pt of 4EZ | Apply as directed. Spray between rows after plants have 3 to 4 leaves and incorporate. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Poast (sethoxydim) | 1 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. Maximum of 3 pt Poast per acre per season. 14-day preharvest interval. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **PUMPKIN AND SQUASH** | | |
| **Postemergence (cont.)** | | |
| Sandea (halosulfuron) | 0.5 to 1 oz | Preemergence application is safer than postemergence. |
| Select (clethodim) | 0.5 pt | Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **SNAP BEANS OR GREEN BEANS** | | |
| **Preemergence** | | |
| Command (clomazone) | 0.4 to 0.67 pt | Surface apply before seeding or after seeding before crop emergence. |
| Dual Magnum (S-metolachlor) or Dual II Magnum | 1 to 2 pt of 7.6EC | |
| Eptam (EPTC) | 3.5 pt of 7EC | Do not use on flat-pod beans. Must be incorporated. |
| Prowl (pendimethalin) | 1.2 to 3.6 pt of 3.3EC | Apply before planting and incorporate. |
| Sandea (halosulfuron) | 0.5 to 1 oz | Apply after planting but before cracking. |
| Treflan, others (trifluralin) | 1 to 1.5 pt of HFP | Must be incorporated. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Assure II (quizalofop) | 6 to 10 oz of 0.88EC | Use crop-oil concentrate, 2 pt per acre. Good on quackgrass. 30-day preharvest interval. |
| Basagran (bentazon) | 1.5 to 2 pt of 4S | Apply when weeds are small. Beans are tolerant after the first-trifoliate leaf has fully expanded. Some injury to beans may occur. |
| Poast (sethoxydim) | 1 to 2.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. Maximum of 4 pt Poast per acre per season. 15-day preharvest interval. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **SNAP BEANS OR GREEN BEANS (CONT.)** | | |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **TABLE BEETS (RED BEETS)** | | |
| **Preemergence** | | |
| Pyramin (pyrazon) | 2.75 to 3.25 qt of 4.5SC, or 4.6 to 5.4 lb of 68DF | Rainfall or irrigation is needed for activation. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Poast (sethoxydim) | 1 to 1.5 pt | Apply to actively growing grasses. Include 1 qt crop-oil concentrate per acre. |
| Pyramin (pyrazon) | 3.5 qt of 4.2FL | Timing is very important. Treat when beets have 2 expanded leaves and weeds have 2 to 4 leaves. |
| Select (clethodim) | 0.5 pt | Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate. |
| Spin-aid (phenmediphon) | 3 to 6 pt of 1.3EC | Apply after beets have 4 leaves. |
| Stringer (clopyralid) | ½ pt | Do not apply within 30 days of harvest. |
| **Stale seedbed** | | |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |
| **TOMATO** | | |
| **Preemergence** | | |
| Devrinol (napropamide) | 2 to 4 lb of 50DF | Must be incorporated. |
| Dual Magnum (metolachlor) | 1 to 2 pt | Apply preplant before transplanting. Do not apply when cool, wet conditions exist. |
| Sencor (metribuzin) | 0.5 to 1 pt of 4L, or 0.33 to 0.66 lb of 75DF | Apply to transplanted tomatoes only. May be incorporated. |

**Table 4. Herbicide rates and guidelines for use in vegetable crops (cont.)**

| Herbicide | Rate of product per broadcast acre | Remarks |
|---|---|---|
| **TOMATO** | | |
| **Preemergence (cont.)** | | |
| Prefar (bensulide) | 4 to 5 qt of 4EC | Incorporate or irrigate in. Do not plant other than specified crops for 18 months after treatment. |
| Sandea (halosulfuron) | ½ to 1 oz | Can be applied preplant under plastic mulch. Wait 7 days before planting. |
| Treflan, others (trifluralin) | 1 to 2 pt of HFP | Must be incorporated. For direct-seeded plants, apply at blocking or thinning as a directed spray between rows. |
| **Postemergence** | | |
| Aim (carfentrazone) | 2 fl oz | Apply with hooded sprayers as a directed application between crop rows. Weeds must be actively growing and less than 4 inches tall. Use crop-oil concentrate or nonionic surfactant. |
| Sencor (metribuzin) | 0.5 to 0.75 pt of 4L, or 0.33 to 0.67 lb of 75DF | Plants must be established; see label. Apply only after 3 successive days of sunny weather. |
| Matrix (rimsulfuron) | 2 oz | Processing tomatoes only. Include 0.25% nonionic surfactant. |
| Poast (sethoxydim) | 1.0 to 1.5 pt of 1.5EC | Use crop-oil concentrate, 2 pt per acre. Maximum of 4.5 pt Poast per acre per season. 20-day preharvest interval. |
| Sandea (halosulfuron) | 0.5 to 1 oz | Transplants only. Apply 4 days after transplanting. Can be applied as over-the-top application. |
| Select (clethodim) | 0.5 pt | Apply to actively growing grasses. Multiple applications may be necessary to control perennial grasses. Include 1% crop-oil concentrate. |
| **Stale seedbed** | | |
| Gramoxone Max (paraquat) | 1.5 to 2.7 pt | See discussion of reduced-tillage systems. |
| Roundup Ultra Max, Touchdown, others (glyphosate) | 1.5 to 3 qt | See discussion of reduced-tillage systems. |

**Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops**

| | Weeds controlled | |
|---|---|---|
| Herbicide | Grasses | Broadleaves |
| 2,4-D amine | | carpetweed, dandelion, dock, galinsoga, jimsonweed, lambsquarters, morningglory, pigweed, plantain, ragweed, smartweed, thistle, wild mustard |
| Accent (nicosulfuron) | barnyardgrass, fall panicum, foxtail, johnsongrass, quackgrass, sandbur, shattercane, sorghum almum, wild proso millet | burcucumber, jimsonweed, morningglory, pigweed, smartweed |
| Aim (carfentrazone) | | lambsquarters, morningglory, nightshade, pigweed, velvetleaf |
| Alanap (naptalam) | | carpetweed, chickweed, cocklebur, hairy galinsoga, lambsquarters, purslane, ragweed |
| Assure (quizalofop) | fall panicum, foxtail, johnsongrass, quackgrass, sandbar, shattercane, volunteer grains, wild proso millet, witchgrass | |
| Balan (benefin) | annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass | carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane |
| Balance (isoxaflutole) | barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, shattercane, witchgrass | galinsoga, jimsonweed, lambsquarters, morningglory, nightshade, pigweed, purslane, ragweed, smartweed, sunflower, velvetleaf |
| Banvel, Clarity (dicamba) | | cocklebur, dandelion, dock, fleabane, jimsonweed, ladysthumb, lambsquarters, milkweed, morningglory, mustard, nightshade, pigweed, prickly lettuce, ragweed, smartweed, velvetleaf |
| Basagran (bentazon) | | Canada thistle, cocklebur, galinsoga, jimsonweed, lambsquarters, purslane, ragweed, smartweed, velvetleaf, wild mustard |
| Beacon (primisulfuron) | fall panicum, foxtail, johnsongrass, quackgrass, sandbur, shattercane | burcucumber, cocklebur, horsenettle, horseweed, jimsonweed, kochia, lambsquarters, morningglory, nightshade, pigweed, prickly sida, puncturevine, ragweed, smartweed, sunflower |
| Buctril (bromoxynil) | | annual morningglory, cocklebur, jimsonweed, lambsquarters, mustard, nightshade, pennycress, pigweed, smartweed |

**Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)**

| | Weeds controlled | |
|---|---|---|
| Herbicide | Grasses | Broadleaves |
| Callisto (mesotrione) | crabgrass | amaranth, cocklebur, horsenettle, jimsonweed, lambsquarters, nightshade, pigweed, ragweed, smartweed |
| Command (clomazone) | barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass | jimsonweed, lambsquarters, purslane, ragweed, smartweed, velvetleaf |
| Curbit (ethalfluralin) | annual bluegrass, barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, seedling johnsongrass, shattercane, witchgrass | carpetweed, chickweed, lambsquarters, nightshade, pigweed, purslane, wild buckwheat |
| Dacthal (DCPA) | barnyardgrass, crabgrass, foxtail, goosegrass, sandbur | carpetweed, knotweed, lambsquarters, pigweed, purslane |
| Devrinol (napropamide) | barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass, weedy brome | chickweed, common groundsel, lambsquarters, pigweed, prickly lettuce, prostrate knotweed, purslane |
| Distinct (diflufenzopyr + dicamba) | | cocklebur, horseweed, ladysthumb, lambsquarters, morningglory, nightshade, pigweed, ragweed, smartweed, thistle, velvetleaf, waterhemp |
| Dual Magnum (*S*-metolachlor) | barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass, yellow nutsedge | carpetweed, galinsoga, nightshade, pigweed |
| Eptam (EPTC) | annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, shattercane, witchgrass | annual morningglory, carpetweed, chickweed, lambsquarters, nightshade, purslane |
| Eradicane Extra (EPTC + safener + extender) | annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass, volunteer small grains | annual morningglory, carpetweed, lambsquarters, nightshade, pigweed, purslane, velvetleaf |
| Fusilade DX (fluazifop-butyl) | barnyardgrass, bermudagrass, crabgrass, fall panicum, foxtail, goosegrass, johnsongrass, volunteer cereals, wild proso millet, witchgrass | |
| Goal (oxyfluorfen) | | black nightshade, common groundsel, evening primrose, pigweed, purslane, shepherd's-purse |
| Gramoxone Max (paraquat) | most annual grasses and broadleaves | See discussion of reduced-tillage systems. |

**Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)**

| | Weeds controlled | |
|---|---|---|
| Herbicide | Grasses | Broadleaves |
| Harness, others (acetolachlor) | barnyardgrass, crabgrass, cupgrass, foxtail, goosegrass, panicum, sandbur | carpetweed, galinsoga, henbit, lambsquarters, nightshade, pigweed, ragweed |
| Karmex, others (diuron) | annual bluegrass, barnyardgrass, crabgrass, foxtail | chickweed, mustard, pennycress, pigweed, purslane, ragweed, velvetleaf |
| Kerb (pronamide) | annual bluegrass, barnyardgrass, brome, foxtail, goosegrass, panicum, volunteer small grains | carpetweed, chickweed, henbit, knotweed, lambsquarters, morningglory, nightshade, purslane |
| Lasso, others (alachlor) | barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, witchgrass | carpetweed, galinsoga, nightshade, pigweed, purslane |
| Linex or Lorox (linuron) | barnyardgrass, crabgrass, fall panicum, goosegrass | annual morningglory, carpetweed, cocklebur, groundsel, lambsquarters, mustard, pigweed, prickly sida, purslane, smartweed, velvetleaf |
| Matrix (rimsulfuron) | barnyardgrass, foxtail, goosegrass | chickweed, cocklebur, galinsoga, ladysthumb, mustard, pigweed, smartweed, velvetleaf |
| Outlook (dimethenamid-P) | barnyardgrass, crabgrass, foxtail, goosegrass, witchgrass | carpetweed, pigweed, purslane, spurge |
| Permit, Sandea (halosulfuron) | | cocklebur, lambsquarters, nutsedge, pigweed, ragweed, smartweed, sunflower, velvetleaf |
| Poast (sethoxydim) | barnyardgrass, bermudagrass, crabgrass, fall panicum, foxtail, goosegrass, johnsongrass, quackgrass, volunteer cereals, wild proso millet, witchgrass | |
| Prefar (bensulide) | crabgrass, fall panicum, foxtail, goosegrass | |
| Prowl (pendimethalin) | barnyardgrass, crabgrass, fall panicum, foxtail | carpetweed, lambsquarters, pigweed, purslane |
| Pursuit (imazethapyr) | | kochia, nightshade, pigweed, wild mustard |
| Pyramin (pyrazon) | | henbit, lambsquarters, mustard, nightshade, pigweed, purslane, ragweed, shepherd's-purse, smartweed |
| Raptor (imazamox) | barnyardgrass, brome, foxtail, shattercane, volunteer cereals | cocklebur, jimsonweed, lambsquarters, morningglory, mustard, nightshade, pigweed |
| Resource (flumiclorac) | | jimsonweed, pigweed, prickly sida, ragweed, velvetleaf |

**Table 5. Weed susceptibility to herbicides labeled for use in vegetable crops (cont.)**

| | Weeds controlled | |
|---|---|---|
| Herbicide | Grasses | Broadleaves |
| Roundup Ultra Max, Touchdown, others (glyphosate) | most annual and perennial grasses and broadleaves | See discussion of reduced-tillage systems. |
| Select (clethodim) | barnyardgrass, bluegrass, crabgrass, downy brome, fall panicum, foxtail, goosegrass, sandbur, shattercane, volunteer cereals, wild proso millet, wooly cupgrass | |
| Sencor (metribuzin) | crabgrass, downy brome, foxtail, seedling johnsongrass | chickweed, jimsonweed, lambsquarters, pepperweed, pigweed, prickly sida, purslane, ragweed, smartweed |
| Sinbar (terbacil) | annual bluegrass, barnyardgrass, crabgrass, foxtail, seedling johnsongrass | chickweed, dandelion, henbit, jimsonweed, knotweed, lambsquarters, pepperweed, pigweed, plantain, purslane, ragweed, shepherd's-purse, wild mustard |
| Spartan | | amaranth, cocklebur, galinsoga, jimsonweed, ladysthumb, lambsquarters, morningglory, nightshade, pigweed, purslane, shepard's-purse, sida, smartweed |
| Spin-aid (phenmedipham) | | chickweed, groundcherry, lambsquarters, purslane, ragweed, shepherd's-purse, wild mustard |
| Stringer (clopyralid) | | Canada thistle, cocklebur, dandelion, dock, horseweed, jimsonweed, ladysthumb, nightshade, prickly lettuce, ragweed, sorrel, sowthistle, wild buckwheat |
| Sutan+ (butylate + safener) | barnyardgrass, crabgrass, fall panicum, foxtail, goosegrass, shattercane, seedling johnsongrass | |
| Thistrol (MCPB) | | annual morningglory, Canada thistle, lambsquarters, pigweed, smartweed, sowthistle |
| Touchdown (glyphosate) | many annual and perennial grasses and broadleaves | See discussion of reduced-tillage systems. |
| Treflan (trifluralin) | annual bluegrass, barnyardgrass, crabgrass, foxtail, goosegrass, seedling johnsongrass | carpetweed, chickweed, knotweed, lambsquarters, pigweed, purslane |

**Table 6. Common names of herbicides and corresponding trade names**

| Common name | Trade name | Common name | Trade name |
|---|---|---|---|
| 2,4-D amine | several names | halosulfuron | Permit, Sandea |
| acetolachlor | Harness, others | imazamox | Raptor |
| alachlor | Lasso, others | imazethapyr | Pursuit |
| atrazine | AAtrex, others | isoxaflutole | Balance |
| benefin | Balan | linuron | Linex, Lorox |
| bensulide | Prefar | MCPB | Thistrol |
| bentazon | Basagran | mesotrione | Callisto |
| bromoxynil | Buctril | metribuzin | Sencor |
| butylate + safener | Sutan+ | napropamide | Devrinol |
| carfentrazone | Aim | naptalam | Alanap |
| clethodim | Select | nicosulfuron | Accent |
| clomazone | Command | oxyfluorfen | Goal |
| clopyralid | Stringer | paraquat | Gramoxone Max |
| DCPA | Dacthal | pendimethalin | Prowl |
| dicamba | Banvel, Clarity | phenmedipham | Spin-aid |
| diflufenzopyr + dicamba | Distinct | primisulfuron | Beacon |
| dimethenamid | Frontier, Outlook | pronamide | Kerb |
| diuron | Karmex, others | pyrazon | Pyramin |
| EPTC | Eptam | quizalofop | Assure II |
| EPTC + safener + extender | Eradicane Extra | rimsulfuron | Matrix |
| ethalfluralin | Curbit | sethoxydim | Poast |
| fluazifop-butyl | Fusilade DX | *S*-metolachlor | Dual Magnum |
| flumiclorac | Resource | sulfentrazone | Spartan |
| glyphosate | Roundup Ultra Max, Touchdown | terbacil | Sinbar |
| | | trifluralin | Treflan, others |

## Environmental and Health Hazards of Herbicides

Nontargeted effects can occur from the use of herbicides. With the increased attention directed toward such nontargeted effects, it is very important to educate yourself and consider nontargeted effects when designing weed-management systems. This overview discusses some of the potential environmental and health hazards of herbicides. More detailed information is contained in herbicide labels, other chapters of this handbook, and trade publications.

### Environmental Hazards

Adverse environmental effects from herbicides can have long-term consequences that are difficult to correct and must be avoided. Some environmental hazards, such as herbicide drift and carryover, affect mainly your operation, while others, such as water contamination, affect all the residents of Illinois. The following section discusses some of the potential hazards and methods to avoid them.

**Herbicide Carryover.** Herbicide carryover from persistent herbicides is a particular problem to growers of vegetable crops. Some vegetable-crop herbicides and many common soybean, corn, and wheat herbicides can persist and injure following crops. Persistent herbicides can kill vegetable plants, reduce growth, affect fruiting, or injure root systems. Root-system injury may not show up until the plants are under stress and the plants suddenly die.

Generally, the biggest problems are ALS-inhibiting herbicides (sulfonylureas and imidazolinones). ALS-inhibiting herbicides can be used on corn, soybeans, and wheat. Examples of sulfonylurea herbicides are Classic, Canopy, and Accent, while some imidazolinones are Pursuit, Scepter, and Raptor. These herbicides inhibit branch-chain amino acid synthesis. Injury from ALS-inhibiting herbicides appears as chlorosis of the growing points and new growth, along with root-growth inhibition. Another herbicide that can persist and injure vegetable crops is atrazine. It inhibits photosynthesis in plants, causing the older leaves to turn yellow. Atrazine is a very common corn (including

*(Text continues on page 265.)*

**Table 7. Rotation restrictions for common vegetable crops**

| Herbicide | | | | Rotation restriction (months)[c] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trade name | Active ingredient | Site of action[a] | Crop use[b] | Sweet corn | Pop-corn | Dry beans | Snap beans | Peas | Potato | Tomato | Pepper | Cu-cum-bers | Pump-kins | Water-melon | Cole crops |
| AAtrex, others | atrazine | PSI | c | AT | AT | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |
| Accent | nicosulfuron | ALSI | c | 10[d] | 10 | 10 | 10 | 10 | 10/18[e] | 10/18 | 10/18 | 10/18 | 10/18 | 10/18 | 10/18 |
| Assert | toluic acid | ALSI | w | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Basis | rimsulfuron + thifensulfuron | ALSI | c | 10 | 10 | 8 | 8 | 8 | 4 | 18 | 18 | 18 | 18 | 18 | 18 |
| Beacon | primisulfuron | ALSI | c | 8 | 8 | 8 | 18 | 8 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Bicep | atrazine + metolachlor | PSI + CHA | c | AT | AT | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |
| Broadstrike + Dual | flumetsulam + metolachlor | ALSI CHA | c, s | 18 | 9 | 4 | 26FB | 4 | 12 | 26FB | 26FB | 26FB | 26FB | 26FB | 26FB |
| Broadstrike + Treflan | flumetsulam + trifluralin | ALSI DNA | c | 18 | 9 | 4 | 26FB | 4 | 12 | 26FB | 26FB | 26FB | 26FB | 26FB | 26FB |
| Canopy | chlorimuron + metribuzin | ALSI PSI | s | 18 | NY | 12 | 12 | 12 | 30 | 10[f] | 30 | 18 | 18 | 18 | 30 |
| Canopy XL | chlorimuron + sulfentrazone | ALSI CBI | s | 18 | NY | 12 | 30 | 30 | 30 | 12[f] | 30 | 18 | 30 | 18 | 18/30[g] |
| Classic | chlorimuron | ALSI | s | 18 | NY | 9 | 9 | 9 | 30 | 9[f] | 30 | 18 | 18 | 18 | 18/30[g] |
| Command | clomazone | PBI | s | 9 | 9 | 9 | 9 | AT[h] | 12 | 9[f] | AT | 9 | AT | 9 | 12 |
| Commence | clomazone + trifluralin | PBI DNA | s | 9 | 9 | 9 | NNY | 9 | 9 | 9[f] | 9 | 9 | 9 | 9 | NNY |
| Concert SP | thifensulfuron + chlorimuron | ALSI | s | 9FB | 9FB | 9 | 9FB | 9FB | 9FB | 9[f] | 9FB | 9FB | 9FB | 9FB | 9FB |
| Contour | imazethapyr | ALSI | c | 18 | 18 | 9 | 40FB | 9 | 26 | 40FB | 40FB | 40FB | 40FB | 40FB | 40FB |
| Cover, others | sulfentrazone | CBI | s | 18 | NY | 12 | 30 | 30 | 30 | 30 | 30 | 18 | 18 | 18 | 18/30 |
| Detail | imazaquin + dimethenamid | ALSI CHA | s | 18 | 18 | 11 | 18 | 18 | 18/26[i] | 18/26 | 18 | 18 | 18 | 18 | 18/26 |
| DoublePlay | EPTC + acetochlor | THC | c | NNY | AT | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |

**Table 7. Rotation restrictions for common vegetable crops (cont.)**

| Herbicide | | | | Rotation restriction (months)[c] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trade name | Active ingredient | Site of action[a] | Crop use[b] | Sweet corn | Pop-corn | Dry beans | Snap beans | Peas | Potato | Tomato | Pepper | Cu-cum-bers | Pump-kins | Water-melon | Cole crops |
| Express | tribenuron | ALSI | w | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Finesse | chlorsulfuron + metsulfuron | ALSI | w | FB | FB | FB | FB | FB | FB | FB | FB | FB | FB | FB | FB |
| FirstRate | cloransulam | ALSI | s | 30 | 9 | 9 | 30 | 9 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| FlexStar | fomesafen | CBI | s | 10 | 10 | 10 | 10 | 10 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Frontier | dimethenamid | CHA | c, s | AT | AT | AT | NY | NY | NY | NY | NY | NY | NY | NY | NY |
| Harmony Extra | thifensulfuron + tribenuron | ALSI | w | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Harness | acetochlor | CHA | c | NY | AT | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |
| Hornet | flumetsulam | ALSI | c | 18 | 10.5 | 10.5 | 26FB | 18 | 18 | 26FB | 26FB | 26FB | 26FB | 26FB | 26FB |
| Lariat, Bullet | atrazine + alachlor | PSI CHA | c | AT | AT | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |
| Liberty | glufosinate | AASI | c, s | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Lightning | imazethapyr + imazapyr | ALSI | c | 18 | 18 | 9.5 | 40FB | 9.5 | 26 | 40FB | 40FB | 40FB | 40FB | 40FB | 40FB |
| Marksman | atrazine + dicamba | PSI GR | c | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |
| Passport | imazethapyr trifluralin | ALSI DNA | s | 18 | 18 | AT | AT | AT | 26 | 26 | 26 | 18 | 18 | 18 | 26 |
| Permit | halosulfuron | ALSI | c | 3 | 3 | 9 | 9 | 9 | 9 | 6[f] | 10 | 9 | 9 | 36 | 11/18 |
| Pinnacle | thifensulfuron | ALSI | s | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Pursuit | imazethapyr | ALSI | c, s | 18[j] | 18[j] | 4 | 4 | 40FB | 40FB | 40FB | 40FB | 40FB | 40FB | 40FB | 40FB |
| Pursuit Plus | imazethapyr pendimethalin | ALSI DNA | c, s | 18 | 18 | 4 | 4 | 40FB | 26 | 40FB | 40FB | 40FB | 40FB | 40FB | 40FB |
| Python | flumetsulam | ALSI | c, s | 18 | 9 | 4 | 26FB | 4 | 12 | 26FB | 26FB | 26FB | 26FB | 26FB | 26FB |
| Raptor | imazamox | ALSI | s | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9/26FB[k] |
| Reflex | fomesafen | CBI | s | 10 | 10 | 10 | 10 | 10 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| Reliance STS | thifensulfuron | ALSI | s | 9/18[l] | 9 | 9 | 9 | 9 | 30 | 9[f] | 30 | 9 | 9 | 9 | 18/30[g] |
| Resolve | imazethapyr dicamba | ALSI GR | c | 9/18 | 18 | 9.5 | 9.5 | 9.5 | 26 | 40FB | 40FB | 40FB | 40FB | 40FB | 40FB |
| Scepter | imazaquin | ALSI | s | 18 | 18 | 11 | 11 | 11 | 18/26[l] | 18/26 | 18 | 18 | 18 | 18 | 18/26 |
| Scorpion II | flumetsulam + clopyralid | ALSI GR | c | 10.5 | 10.5 | 10.5 | 26FB | 18 | 18 | 26FB | 26FB | 26FB | 26FB | 26FB | 26FB |

**Table 7. Rotation restrictions for common vegetable crops (cont.)**

| Herbicide | | | | Rotation restriction (months)[c] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trade name | Active ingredient | Site of action[a] | Crop use[b] | Sweet corn | Pop-corn | Dry beans | Snap beans | Peas | Potato | Tomato | Pepper | Cu-cum-bers | Pump-kins | Water-melon | Cole crops |
| Shotgun | atrazine + 2,4D | PSI GR | c | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |
| Squadron | imazaquin + pendimethalin | ALSI DNA | s | 18 | 18 | 11 | 11 | 11 | 18/26[i] | 18/26 | 18 | 18 | 18 | 18 | 18/26 |
| Steel | imazaquin | ALSI | s | 18/26[i] | 18/26 | 11 | 11 | 11 | 26 | 40FB | 40FB | 40FB | 40FB | 40FB | 40FB |
| | imazethapyr | ALSI | | | | | | | | | | | | | |
| | pendimethalin | DNA | | | | | | | | | | | | | |
| Stringer | clopyralid | GR | c, w | 10.5 | 10.5 | 10.5 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 10.5 |
| Surpass 100 | acetolachlor + atrazine | CHA | c | NNY | AT | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |
| Synchrony STS | chlorimuron | ALSI | s | 18 | 9 | 9 | 9 | 9 | 30 | 9[f] | 30 | 18 | 18 | 18 | 18/30[g] |
| TopNotch | acetolachlor | CHA | c | NNY | AT | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY | NNY |
| Touchdown | sulfonium | ALSI | c, s | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Tri-Scept | imazaquin + trifluralin | ALSI DNA | s | 18 | 18 | 11 | 11 | 11 | 18/26[i] | 18/26 | 18 | 18 | 18 | 18 | 18/26 |
| Turbo | metolachlor + metribuzin | CHA | s | 8 | 8 | 12 | 12 | 8 | 8 | 12 | 12 | 12 | 12 | 12 | 12 |

[a]Sites of action include: PSI = photosynthetic inhibitor; ALSI = ALS-inhibiting; CHA = chloroacetamide; THC = thiocarbamate; DNA = dinitroaniline; CBI = chlorophyll-biosynthesis inhibitor; PBI = pigment-biosynthesis inhibitor; AASI = amino acid–synthesis inhibitor; GR = growth regulator.

[b]Crops include: c = corn; s = soybean; w = wheat.

[c]Rotation restrictions include: AT = anytime; NNY = not next year; FB = field bioassay (the first number is the months that must pass before the bioassay); NY = next year.

[d]Except Merit, Carvinal, Sweet Success sweet corn cultivars, where the restriction is 15 months.

[e]The rotation restriction is 10 months at pH ≤ 6.5 and 18 months at pH > 6.5.

[f]Transplanted tomatoes only.

[g]Cabbage/other cole crops.

[h]If more than 1.33 pt/acre, then 9 months.

[i]Rotation restriction for southern or northern Illinois, respectively.

[j]Some sweet corn and popcorn varieties may be planted the year following an application of Pursuit.

[k]Cabbage and broccoli may be planted 9 months after Raptor applications. Other cole crops have a 26-month rotation restriction and require a field bioassay.

[l]9 months for processing sweet corn or 18 months for sweet corn.

sweet corn and popcorn) herbicide that is contained in a wide variety of products.

Some ALS-inhibiting herbicides have a very long persistence. Generally, rotation restrictions provide an indication of how long after its application a herbicide persists. For example, Passport, Pursuit, and others require that you wait 40 months after they are applied (Table 7) and then successfully conduct a field bioassay before planting vegetable crops. Atrazine generally requires that you plant no other crops the year following an application.

Herbicide persistence is dependent on soil and environmental factors. Breakdown of herbicides in the soil occurs either by microbial degradation or chemical hydrolysis. Both factors require that the soil be moist and temperatures warm. Thus, cool temperatures and dry conditions slow herbicide degradation. Soil pH and organic matter are also important for herbicide degradation. For example, at pHs above 6.5, degradation of Accent is slowed considerably. Because these soil and environmental influences affect herbicide degradation and persistence, rotation restrictions should be used as minimum guidelines.

What is a field bioassay? It is the planting of a test strip of the sensitive vegetable crop across the treated field and letting it grow to maturity. It is a way of determining if sufficient herbicide residual remains to injure a sensitive follow crop. Field bioassays should be conducted after you have waited the number of months prescribed by the herbicide label.

How do you conduct a bioassay? Generally, strips of a test crop are planted across a field. Several rows of the test crop should be planted in each strip, and several strips should be planted in the field. The test strips should be planted perpendicular to the direction the herbicide was originally applied. Test strips should include field margins and ends, low areas, knolls, and sections of the field varying in soil characteristics such as type, organic matter, and pH.

Avoid carryover because correcting carryover problems once they occur is virtually impossible. The best solution for avoiding herbicide carryover injury is selecting fields that have not had persistent herbicides. Fields that previously were in pasture, CRP land, or vegetables (besides sweet corn) are unlikely to have persistent herbicides. Many wheat herbicides have short persistence and do not injure following crops. If you must use fields that had corn or soybeans, choose those having Roundup Ready crops. Roundup tightly binds to the soil and does not injure rotational crops.

**Herbicide Drift.** Another frequent hazard to vegetable growers is crop injury from herbicide drift. The term *drift* refers to movement of herbicides off the site where they were applied. Drift can occur either during herbicide application (spray drift) or because the herbicide volatilizes after being applied to plants (vapor drift). Both types of drift can injure your vegetable crops. Vegetables are extremely sensitive to some herbicides, such as growth regulators. This extreme sensitivity means that very low concentrations of growth-regulator herbicides can drift and injure your crop.

What are growth-regulator herbicides? They are herbicides that mimic auxins. Auxins are natural chemicals that govern growth in plants. They regulate shoot and root response to gravity, shoot branching, leaf growth, and fruit development. Tolerant crops are able to degrade growth regulators into nonactive compounds, while most vegetables cannot metabolize these herbicides. Growth-regulator herbicides are inexpensive and widely applied to corn, soybeans, wheat, turf, and rights-of-way. In agricultural settings, growth-regulator herbicides are used before planting for burndown in no-till corn and soybeans, at planting in corn, and postemergence in both corn and wheat. Growth-regulator herbicides used in turf or by railroads, utilities, and townships on rights-of-way can also drift to injure vegetables. Growth-regulator herbicides can drift up to a mile and cause serious damage to grapes, tomatoes, peppers, other vegetables, fruit crops, and ornamental plants. Table 8 lists the trade names of some growth-regulator herbicides.

The most common growth-regulator herbicides are 2,4-D and dicamba. The ability of 2,4-D and dicamba to drift or volatilize depends on the formulation. The ester formulations of 2,4-D (that is, Barrage, Estron, and Salvo) are more likely to volatilize and drift than are amine formulations (that is, Formula 40, Amine 4, and Savage). Ester formulations of 2,4-D are widely used because they have cheaper cost, greater penetration, and better activity against weeds than other formulations. Dicamba formulations also differ in their volatility. The older Banvel formulation appears to volatilize more than the newer Clarity formulation of dicamba.

Are other herbicides besides growth regulators likely to injure vegetables? Generally, despite their reactions to growth regulators, vegetable crops are not extremely sensitive to other herbicides, compared to the reactions of other crops (Table 9). The other herbicides of concern are glyphosate and ALS inhibitors. Both groups of herbicides translocate to and kill growing points of plants. Glyphosate is the active ingredient in Roundup Ultra Max and similar products. Glyphosate inhibits synthesis of aromatic amino acids (that is, phenylalanine and others). Roundup traditionally has been used as a nonselective herbicide for burndown prior to planting or after harvest. These

**Table 8. Common and trade names of some herbicides that might injure vegetable crops (This list is not all-inclusive. Other herbicides may also injure vegetables.)**

| *Growth regulators* | | | *Glyphosate* | *ALS inhibitors* | |
|---|---|---|---|---|---|
| 2,4-D | Dicamba | Others | | Sulfonylurea | Imidazolinone |
| Amine 4 | Banvel | Amitrole T | Accord | Accent | Assert |
| Barrage | Clarity | Rhomene | Bronco | Ally | Contour* |
| Brush-Rhap | Fallow Master* | Sword | Landmaster* | Basis | Lightning |
| Crossbow* | Marksman* | Telone C-17 | Protocol | Basis Gold* | Pursuit |
| Esteron | OpTill* | | Ranger | Beacon | Pursuit Plus |
| Formula 40 | Resolve* | | Rodeo | Canopy* | Raptor |
| Grazon* | | | Roundup Ultra Max | Classic | Resolve |
| Landmaster* | | | | Concert* | Scepter |
| Phenoxy 088* | | *Pigment inhibitors* | | Escort | Squadron* |
| Salvo | | | | Exceed | Steel* |
| Scorpion III* | | Command | | Express | Tri-Scept* |
| Shotgun* | | Commence | | Finesse* | |
| Tiller* | | | | Glean | |
| Weedar | | | | Harmony | |
| Weedmaster* | | | | Matrix | |
| Weedone | | | | Oust | |
| Weedone 638* | | | | Permit | |
| 2 Plus 2 | | | | Pinnacle | |
| | | | | Synchrony* | |

*A prepackaged mixture also containing other active ingredients.

application times were usually not a problem because most vegetables were not actively growing when glyphosate was applied. This situation has dramatically changed with the widespread use of Roundup-Ready corn and soybeans. Now, Roundup is often applied when vegetables are actively growing and fruiting. Vegetable crops are likely to be injured only by spray drift from nearby applications. The injury symptoms include chlorosis and death of growing points, misshapen growth, reduced survival, less fruiting, and lower fruit quality.

Herbicides containing clomazone (Command and Commence) can cause bleaching of nearby sensitive plants. This herbicide inhibits pigment synthesis in plants. Plants usually recover from the bleaching caused by clomazone. Often yields are not effected by the drift. Older formulations of Command were volatile and required incorporation soon after application. The current 3ME formulation of Command is less volatile and less likely to drift and injure susceptible plants.

Many vegetable crops are also sensitive to acetolactate synthase (ALS)–inhibiting herbicides. These herbicides are sulfonylureas (that is, Classic, Accent, and Permit) and imidazolinones (that is, Pursuit and Scepter). They inhibit the key enzyme (acetolactate synthase) that controls branch-chain amino acid synthesis. ALS inhibitors are widely used in corn, soybean, and wheat production. They are applied both before planting and postemergence at extremely low rates. The high biological activity of ALS-inhibiting herbicides increases the likelihood of drift. Injury symptoms from ALS-inhibiting herbicides are similar to those from glyphosate, except root injury is more likely. Generally, it is believed that vegetable-crop injury from ALS inhibitors is likely only from very nearby applications.

What can you do about herbicide drift? You must work to prevent drift because once vegetables are injured there is no cure. Do not cause a drift problem yourself. Work with your neighbors to minimize the potential for drift from nearby applications. Spray only on calm days, and use drift inhibitors when appropriate. Minimize drift by applying herbicides with nozzles that produce large droplets. Use less-volatile forms of herbicides, especially 2,4-D. Spray Command (clomazone), dicamba, and 2,4-D when the temperature is expected to be lower than 80°F for several days after treatment. Avoid applying Command or other volatile soil-applied herbicides to wet soils, and incorporate soon after application. Apply herbicides unlikely to injure your vegetables (Table 9). Use preemergent herbicides such as Lasso, Dual, Harness, Frontier, Treflan, and Prowl, which are effective only against emerging seedlings. Drift from photosynthetic

**Table 9. Some herbicides that can be used on corn or soybeans and that are unlikely to drift and injure vegetables**

| Corn | Soybeans |
|---|---|
| *Preemergence* | |
| Atrazine | Broadstrike |
| Dual | Dual |
| Eradicane | Frontier |
| Frontier | Harness |
| Harness | Lasso |
| Lasso | Lexone/Sencor |
| | Prowl |
| | Treflan |
| *Postemergence* | |
| Atrazine | Basagran |
| Basagran | Blazer |
| Buctril | Poast |
| | Prism |
| | Reflex |
| | Select |

inhibitors such as Attrex (atrazine), Sencor, and Lorox, along with contact herbicides such as Basagran, Blazer, Reflex, and Authority, does not cause long-term damage to vegetables. These chemicals might cause leaf burn but will not translocate to growing points or fruit.

**Spray-Tank Residuals.** Dicamba or 2,4-D residues in spray tanks also can injure susceptible vegetable crops. Carefully follow label directions for cleaning spray equipment after using dicamba or 2,4-D. If possible, do not use the same spray equipment to apply 2,4-D or dicamba that you use to apply other pesticides.

**Herbicide Resistance.** There are now more than 50 documented reports worldwide of weeds that have developed resistance to herbicides. Herbicide resistance tends to occur when a persistent herbicide is used year after year in the same field. Thus, continued use of the same herbicide on a perennial crop such as asparagus should be avoided. Many of the resistance problems have occurred with triazine herbicides, such as simazine and atrazine. The labels of those herbicides contain information about avoiding resistance problems.

Approaches to avoid herbicide resistance combine herbicides with mechanical (cultivation) and cultural (crop rotation) weed-management practices. Rotate between or use tank mixes of herbicides with different mechanisms of killing the plant. For example, in asparagus, rotate between Sencor and Treflan. Use tillage to control weeds that escape from herbicide applications. Especially important in minimizing any weed resistance that does occur is scouting your fields, paying special attention to any patches of a weed normally controlled by the herbicide.

**Water Quality.** Residues of some herbicides, such as atrazine, metolachlor, alachlor, cyanazine, and metribuzin, have been found in surface water or groundwater. The levels detected have normally been low, but contamination of water resources is a growing concern. For example, groundwater contamination from pesticides and nitrates is of particular concern in areas of the state with sandy soils and shallow groundwater.

Factors determining the potential for groundwater and surface-water contamination include herbicide solubility in water, rate of degradation, volatility, and tendency for the herbicide to attach to soil particles or organic matter. Herbicides that have high water solubility and long persistence are of particular concern.

Site characteristics (soil type, soil depth, water-table depth, slope, and weather) also can lead to contamination of water resources from herbicides. You should be aware of the potential problem of herbicide contamination and take all possible steps to avoid contaminating surface and subsurface water resources.

### Disposing of Herbicides and Containers

**Surplus Herbicides.** If possible, use surplus herbicide mixtures by applying them to labeled crops that have the same weed problems. Never drain surplus pesticides in any location where they can contaminate groundwater or surface-water supplies. Avoid creating surplus tank mixes by accurately measuring the treatment area and mixing the correct amount of pesticide. If a large amount of surplus pesticide is generated, contact the Illinois EPA Division of Land Pollution Control for instructions about disposal.

**Pesticide Containers.** Rinse all empty containers, regardless of their type, three times before disposal. Dump rinse water into the tank. Puncture or break triple-rinsed containers to facilitate drainage and to prevent reuse for any purpose. Then dispose of containers according to label directions and local regulations, with regard for the protection of water resources.

### Health Hazards

Health hazards from exposure to pesticides may be divided into acute and chronic effects, according to the duration and amount of exposure.

**Acute Effects.** Acute effects or poisoning occurs soon after exposure to large amounts of a pesticide. Effects of this type are dangerous to you, your family, and your workers. The potential for human or animal poisoning from pesticides can be reduced by careful storage and handling. Keep pesticides in a separate area, room, or building used only for storage. The storage area should be dry and ventilated.

Keep all entrances to the area locked at all times to protect children, other people, and animals. **Caution**: Do not store herbicides together with insecticides or fungicides. Remove only the pesticide to be used in one day and, after use, return the pesticide to the storage area. Follow label directions when handling pesticides. Pay particular attention to sections on protective-clothing requirements and any field-reentry limitations.

### Herbicide Residues in Vegetables

The issue of pesticide residues in vegetables is currently receiving intense public attention. Many of the herbicides used in vegetable crops are older products that were registered before current toxicological and environmental standards were established by the USEPA. Congress has required the USEPA to re-register these older products to bring the data up to current toxicological and environmental standards, causing some companies to remove products from the market.

Data exist that some herbicides (and other pesticides) potentially cause adverse health effects, such as cancer from chronic (long-term) exposure. There is controversy about the reliability and importance of these data. Groups that are particularly concerned about pesticide residues in vegetables include the National Resources Defense Council, National Coalition Against Misuse of Pesticides, and Americans for Safe Food. Because customers may question you, it is recommended that you stay up-to-date on this issue. The groups listed have information reflecting their views. Information reflecting food industry views is also available from groups such as the Alliance for Food and Fiber, the Food Marketing Institute, and the Center for Produce Quality.

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# 9

# Plant Disease Management for Commercial Vegetable Crops

## Updates for 2006

The following list briefly highlights some of the changes to the chapter for this edition:

- Amistar (azoxystrobin). Amistar, a strobilurin fungicide, has been registered for control of diseases of many vegetables.
- Cabrio (pyraclostrobin). The label of Cabrio has been expanded for use on bulb vegetables (onion, garlic, leek, shallot) to control purple blotch and leaf blight, powdery mildew, rust, downy mildew, and Botrytis leaf blight.
- Forum (dimethomorph). Forum has been labeled for control of diseases of bulbs, vegetables, cucurbits, eggplant, peppers, tomatillo, leafy Brassicas, lettuce, potato, and nonstaked tomato.
- Headline (pyraclostrobin). Headline has been registered for control of Asian soybean rust in beans and peas.
- Phosphorous acid–based fungicides (Agri-Fos, Phostrol, ProPhyt). These fungicides have been registered for control of diseases caused by oomycete pathogens in several vegetables.
- Ranman (cyazofamid). Ranman, a new fungicide, is available for control of diseases of cucurbits, potato, and tomato.
- Tanos (famoxadone + cymoxanil). The label of Tanos has been expanded for control of bacterial fruit blotch and Phytophthora blight of cucurbits; anthracnose, bacterial soft rot, and bacterial spot of peppers; and brown spot of potato.

## Disease Management

Successful control of vegetable diseases requires an integrated program that includes the use of resistant varieties, crop rotation, balanced soil fertility, weed and insect control, and proper crop culture, as well as the proper selection, timing, and method of applying fungicides, bactericides, or nematicides. Economical control depends on establishing an overall disease-management system for the entire farm. Keeping careful records of the crops planted, the problems encountered, and the pesticides used is important.

Because many disease problems originate with seeds or transplants, growers should follow the seed-treatment recommendations given in this chapter and in *Report on Plant Disease (RPD)* no. 915, "Vegetable Seed Treatment" (available from the Department of Crop Sciences, N-533 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801), or be sure to obtain planting material that is certified as disease free.

This chapter lists the registered fungicides and application intervals for various vegetable crops as approved by the Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (USEPA) as of October 20, 2004, to the best of our knowledge. Tables 1 and 2 give the number of days between the last application at the normal rate and harvest, as well as other restrictions to keep residues within the tolerances set by the FDA. Refer to current labels for information on rates, timing, and methods of applica-

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

tion, as well as for information on follow-up crops and other restrictions.

The listing of a chemical as approved for use on a particular crop does not mean that University of Illinois Extension or the Office of Research recommends its use for that crop. Our specific recommendations for disease control are given in Table 3.

In some instances, a tolerance has been set, but a definite interval has not been established. The absence of an interval for a crop in the listings does not necessarily mean that the fungicide may not be used on that crop. To ensure that the crop produced does not exceed the tolerance, the use of the fungicide would require a restriction such as "Do not apply after first blooms appear" or "Do not apply after edible parts form." This information appears on the product label.

In a few cases, the interval and dosage have been established, but the allowable residue concentration has not been determined. Again, this does not mean that the fungicide may not be used on the crops for which the fungicide is labeled. It does mean, however, that until the tolerance is established, it must be considered as zero. These cases are reviewed each year, and some are canceled when the chemical manufacturer supplies the USEPA with additional data.

Growers must follow a program of disease control ensuring that the vegetables produced do not contain excessive fungicide residues. Vegetables marketed with residues exceeding the FDA tolerances may be injurious to consumers, may be confiscated, and may subject the grower to legal action.

*Growers have nothing to fear from the law so long as they use fungicides and other pesticides according to the current labels and only on the crops specified, in the amounts specified, and at the times specified.* The prudent grower keeps a record of the products and trade names used, the percentage of active ingredients, dilutions, rates of application per acre, and dates of application.

## Disease Diagnosis

The first step in an effective disease-management program is proper identification of the problem. This is often the most difficult, but the most important, step. Make every possible effort to ensure that the disease is accurately diagnosed. Failure in accurate identification of the problem could have severe consequences.

## Fungicide Application

We recommend that the following practices be used when applying fungicides.

- Cover the foliage uniformly. *Ground application*—Apply 30 to 50 gallons per acre at 100 to 400 pounds per square inch of pressure unless recommended otherwise. Lowering the volume, pressure, or both may provide adequate coverage; but high-volume, high-pressure applications provide ideal coverage. Make sure the sprayer is functioning properly. Check the nozzles for cleanliness and wear. Boom height, accuracy of pressure gauge, agitation, and calibration should also be checked. *Aerial application*—Apply recommended amounts of pesticide in 3 to 5 gallons of water per acre. Make sure nozzles are properly aligned and clean so that uniform application is achieved. Cover a swath no wider than is reasonable for the aircraft and boom being used. Spray only those fields that are suitable for aerial application. Avoid fields of irregular shape or topography, particularly if they are bounded by power lines, trees, or other obstructions.
- Whenever possible, spray when the air is still or when wind velocity is less than 10 mph.
- Avoid situations where pesticide drift may cause needless problems.
- When it is compatible with the product label, use a spray adjuvant (surfactant). Available surfactants include Bio-Film, Bio 88, Regulaid (for systemic fungicides), Plyac, NuFilm, Chevron Spray Sticker, X-77 Spreader, Triton, and some others. Spray adjuvants are most useful on cabbage, cauliflower, Brussels sprouts, onions, and peppers.

## Soil Fumigation

Follow the manufacturer's directions exactly. Fumigants work best in light, loose soils that are free of trash, clods, and lumps. Avoid recontaminating treated soil. It is best to apply fumigants during the fall before planting. In general, the soil temperature must be at least 55° to 60°F at the 6-inch depth, with a time lapse of 21 to 28 days between treating and seeding. Some fumigants require gas-tight plastic covers. Many fumigants are restricted use chemicals.

## Using Nematicides

Use nematicides only where soil analysis shows a nematode problem to be present. Follow soil sampling instructions in *RPD* no. 1100, "Collecting and Submitting Soil Samples for Nematode Analysis." *RPD* no. 1100 and other *RPD*s are available from the Department of Crop Sciences, N-533 Turner Hall, 1102 S. Goodwin Ave., Urbana, IL 61801.

*(Text continues on page 294.)*

**Table 1. Limitations on days between application and harvest, and other restrictions on using fungicides on vegetables in Illinois**

| Crop | Azoxystrobin[a] | Chlorothalonil[b] | Mancozeb[c] | Maneb[d] | Myclobutanil[e] | Pyraclostrobin[f] | Thiaphanate-methyl[g] | Trifloxystrobin[h] |
|---|---|---|---|---|---|---|---|---|
| Asparagus | ... | ... | A; root dip | ... | 180 | ... | ... | ... |
| Beans (dry lima, snap) | seed[i] | 7 (snap only), B<br>14 (lima, dry), B | ... | 30 (dry only) | 0 | 30 (dry) | 14 (dry, snap)<br>28 (lima) | ... |
| Beet, garden | 0 | ... | ... | ... | ... | 0 | ... | ... |
| Broccoli | ... | 7 | ... | 7 | ... | ... | ... | ... |
| Brussels sprout | ... | 7 | ... | 7 | ... | ... | ... | ... |
| Cabbage | 0 | 7 | ... | 7 | ... | ... | ... | ... |
| Cantaloupe (muskmelon, honeydew melon) | 1 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| Carrot | 0 | 0 | ... | ... | ... | 0 | ... | ... |
| Cauliflower | 0 | 7 | ... | 7 | ... | ... | ... | ... |
| Celery | 0 | 7 | ... | ... | ... | ... | ... | ... |
| Chinese cabbage | 0 | 7 | ... | 10 | ... | ... | ... | ... |
| Corn, sweet and pop | 7 | 14, BE[j] | 7, B | 7, B | ... | ... | ... | ... |
| Cucumber | 1 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| Eggplant | 0 | ... | ... | 5 | ... | 0 | ... | 3 |
| Endive, escarole | 0 | ... | ... | 10 | ... | ... | ... | ... |
| Fennel | 0 | ... | 14 | ... | ... | ... | ... | ... |
| Garlic | 0 | 7 | ... | 7 | ... | 7 | ... | ... |
| Kale | 0 | ... | ... | 10 | ... | ... | ... | ... |
| Kohlrabi | 0 | ... | ... | 7 | ... | ... | ... | ... |
| Leek | 0 | 14 | ... | ... | ... | 7 | ... | ... |
| Lettuce | 0 | ... | ... | 10 | ... | ... | ... | ... |
| Melon | 1 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |
| Mustard greens | 0 | ... | ... | ... | ... | ... | ... | ... |
| Onion | 0 | 7 (dry) | 7, D | 7, D | ... | 7 | ... | ... |
| Parsley | 0 | ... | ... | ... | ... | 0 | ... | ... |
| Parsnip | 0 | 10, B | ... | ... | ... | ... | ... | ... |
| Peas | seed | ... | ... | ... | ... | ... | ... | ... |
| Pepper | 0 | ... | ... | 7 | ... | 0 | ... | 3 |
| Potato, Irish | 14 | 7 | 14, C | 14, C | ... | 3 | ... | ... |
| Pumpkin | 1 | 0 | ... | 5 | 0 | 0 | 0 | 0 |
| Radish | 0 | ... | ... | ... | ... | 0 | ... | ... |
| Shallots | 0 | 14 | ... | ... | ... | 7 | ... | ... |
| Spinach | 0 | ... | ... | ... | ... | ... | ... | ... |
| Squash | 1 | 0 | 5 (summer only) | 5 | 0 | 0 | 0 | 0 |
| Tomato | 0 | 0 | 5 | 5 | 0 | 0 | ... | 3 |
| Turnip, rutabaga | 0 | ... | ... | ... | ... | 0 | ... | ... |
| Watermelon | 1 | 0 | 5 | 5 | 0 | 0 | 0 | 0 |

**Table 1. Limitations on days between application and harvest, and other restrictions on using fungicides on vegetables in Illinois (cont.)**

Numbers indicate days between last application and harvest; 0 = up to harvest; . . . = fungicide is not registered for use on that particular vegetable; A = postharvest application to ferns only or to young plantings that will not be harvested; B = do not feed treated tops or forage to livestock; C = do not use treated seed or seed pieces for feed or food; D = do not apply to exposed bulbs; E = do not ensile treated corn or use as livestock forage.

[a]Azoxystrobin is a strobilurin fungicide sold as Quadris. Azoxystrobin is a preventive fungicide with systemic and curative properties. Do not use azoxystrobin in alternation with other strobilurins, such as trifloxystrobin. Azoxystrobin is extremely phytotoxic to certain apple varieties. Do not spray azoxystrobin where spray drift may reach apple trees. Do not apply more than one application of azoxystrobin before alternating with a fungicide that has a different mode of action. Do not make more than four applications of azoxystrobin or other strobilurin fungicides per crop per acre per year.

[b]Chlorothalonil is a contact-protective fungicide sold as Bravo 500, Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Echo, Terranil 6L, and Terranil 90DF. It is also sold in combination with mefenoxam as Ridomil Gold Bravo.

[c]Mancozeb is a contact-protective fungicide sold as Dithane F-45, Dithane M-45, Dithane DF, Manzate 200DF, and Penncozeb.

[d]Maneb is a contact-protective fungicide sold as Maneb 75DF, Maneb 80WP, and Manex.

[e]Myclobutanil is a systemic, protectant, and curative fungicide sold as Nova.

[f]Pyraclostrobin is a strobilurin fungicide sold as Cabrio and Headline. Pyraclostrobin is a preventive fungicide with systemic and curative properties. Do not alternate pyraclostrobin applications with other strobilurins, such as azoxystrobin and trifloxystrobin. Read and follow label directions for each group of vegetables.

[g]Thiaphanate-methyl is a systemic fungicide sold as Topsin M WSB or Topsin M 70W.

[h]Trifloxystrobin is a strobilurin fungicide sold as Flint. Trifloxystrobin is a preventive fungicide with systemic and curative properties. Do not apply more than one application of trifloxystrobin before alternating with a fungicide that has a different mode of action. Do not make more than four applications of trifloxystrobin or other strobilurin fungicides per crop per acre per year.

[i]Seed treatment.

[j]Do not apply if the crop will be used for processing.

**Table 2. Label information on fungicides and nematicides of less general use**

| Fungicide | Crops and use restrictions |
|---|---|
| **Actigard** (plant activator) (Actigard 50WG) | **Spinach:** downy mildew, white rust, 7 days.[a] **Tomato:** bacterial spot, bacterial speck, 14 days.[a] |
| **Azoxystrobin** (Amistar, Quadris) | **Bulb vegetables** (garlic, leek, onions, shallot); **corn** (pop and sweet); **cucurbits** (cantaloupe, chayote, Chinese waxgourd, cucumber, gourd, honeydew melon, muskmelon, pumpkin, squash, watermelon, zucchini); **eggplant; leafy vegetables** (amaranth, arugula, Brassica leafy green, cardoon, celery, celtuce, chervil, coriander, cress, dandelion, dock, edible chrysanthemum, endive, fennel, lettuce, mint, orach, parsley, purslane, radicchio, rhubarb, spinach, Swiss chard); **okra; pepper; tomatoes; vegetable—root** (beet, burdock, carrot, celeriac, chervil, chicory, ginseng, horseradish, parsley, parsnip, radish, rutabaga, salsify, skirret, turnip); **vegetable—tuberous** (arracacha, arrowroot, artichoke, burdock, canna, cassava, chayote, chufa, dasheen, ginger, leren, potato, sweet potato, tanier, turmeric, yam). Read and follow label directions. |
| (Dynasty) | **Corn** (popcorn and sweet corn); **legume vegetables** (field bean, kidney bean, lima bean, navy bean, pinto bean, runner bean, snap bean, wax bean), chickpea (garbanzo bean), lentil, peas (dwarf pea, edible-pod pea, English pea, field pea, garden pea, green pea, snow pea, sugar snap pea); seed treatment against seedborne and soilborne fungi. |
| (Protégé) | **Curcurbits** (cucumber); **corn** (popcorn and sweet corn); **legume vegetables** (field bean, kidney bean, lima bean, navy bean, pinto bean, runner bean, snap bean, wax bean), chickpea (garbanzo bean), lentil, peas (dwarf pea, edible-pod pea, English pea, garden pea, green pea, snow pea, sugar snap pea); **corn** (popcorn and sweet corn); seed treatment against seedborne and soilborne fungi. |
| **Azoxystrobin + chlorothalonil** (Quadris Opti) | **Bulb vegetables** (leek, onion, shallot); **carrot; celery; cucurbits** (cantaloupe, chayote, Chinese wax gourd, cucumber, gourd, honeydew, *Momordica* spp., muskmelon, watermelon, pumpkin, squash, zucchini); **dry beans** (adzuki bean, broad bean, lablab bean, navy bean, kidney bean, lima bean, moth bean, mung bean, pink bean, pinto bean, tepary bean, urd bean, yardlong bean, rice bean, running bean, jackbean, blackeyed pea, southern catjang pea, chickpea [garbanzo], grain lupin, lupine); **potatoes; tomatoes.** Read and follow label directions. |
| **Azoxystrobin + propiconazole** (Quilt) | **Sweet corn:** eye spot, gray leaf spot, northern corn leaf blight, northern corn leaf spot, rusts, southern corn leaf blight, 14 days.[a] |
| **Bordeaux mixture** (many trade names) | **Asparagus, beans, beet, broccoli, Brussels sprout, cabbage, carrot, casaba melon, celery, collard, crenshaw melon, cress, cucumber, eggplant, honeydew melon, horseradish, kale, muskmelon, mustard, pepper, Persian melon, potato, pumpkin, radish, rape, rutabaga, spinach, squash, tomato, turnip, watermelon.** Read and follow label directions. |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **Boscalid** (Endura) | **Beans** (dry and succulent): Asochyta blight, Botrytis gray mold, rust, white mold, 7 days.[a]<br>**Bulb vegetables** (garlic, leek, onion): purple blotch, Botrytis leaf blight, 7 days.[a]<br>**Carrot:** Alternaria leaf spot, 0 days.[a]<br>**Fruiting vegetables** (eggplant, ground cherry, pepino, pepper, tomatillo, tomato): early blight, Botrytis gray mold, 0 days.[a]<br>**Lettuce:** lettuce drop (*Sclerotinia* spp.), Botrytis rot, Rhizoctonia bottom rot, 14 days.[a]<br>**Potato:** early blight, white mold, 30 days.[a]<br>**Head and stem Brassicas** (broccoli, Brussels sprout, cabbage, Chinese cabbage, Chinese mustard, cauliflower, kohlrabi): Alternaria blight, gray mold, Sclerotinia stem rot, powdery mildew, Rhizoctonia bottom rot, 0 days.[a]<br>**Leafy Brassica green** (broccoliraab, Chinese cabbage, kale, mustard greens, mustard spinach, rape greens): Alternaria blight, gray mold, Sclerotinia stem rot, powdery mildew, Rhizoctonia bottom rot, 14 days. |
| **Captan** (many) | **Beans** (snap, dry, cowpeas), **beet** (garden), **broccoli, Brussels sprout, cabbage, cantaloupe, cauliflower, corn** (sweet), **crucifers** (collard, kale, mustard, radish, rape, turnips), **cucumber, lentils, muskmelon, peas, pepper, pumpkin, spinach, squash, Swiss chard, watermelon:** seed protectant. Read and follow label directions. |
| **Copper fungicides**[b] copper sulfate (many) | **Beans, beet, cantaloupe, carrot, celeriac, celery, cucumber, eggplant, honeydew melon, muskmelon, onion, pea, pepper, Persian melon, potato, pumpkin, spinach, squash, tomato, watermelon.** Read and follow label directions. |
| copper ammonium carbonate (Copper-Count N) | **Beans, cabbage, cantaloupe, carrot, celery, cucurbits, eggplant, honeydew melon, lettuce, onion, peas, pepper, potato, squash, tomato, watermelon.** Read and follow label directions. |
| copper hydroxide (Kocide DF, Kocide 4.5LF, Kocide 101, Kocide 2000) | **Beans, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, cauliflower, celery, cucumber, eggplant, lettuce, muskmelon, onion, peas, pepper, potato, pumpkin, squash, tomato, watermelon.** Read and follow label directions. |
| copper oxychloride (many) | **Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, casaba melon, cauliflower, celery, crenshaw melon, cucumber, eggplant, honeydew melon, lettuce, muskmelon, onion, peas, Persian melon, potato, pumpkin, spinach, squash, tomato, watermelon.** Read and follow label directions. |
| tribasic copper sulfate (many) | Read and follow label directions. |
| **cyazofamid** (Ranman) | **Cucurbits:** downy mildew and Phytophthora blight, 0 days.[a]<br>**Potato:** late blight, 7 days.[a]<br>**Tomato:** late blight, 0 days.[a] |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **Cymoxanil** (Curzate 60DF) | **Cucurbits:** downy mildew, 3 days.[a]<br>**Potato:** late blight, 14 days.[a]<br>**Tomato:** late blight, 3 days.[a]<br>Read and follow label directions. |
| **Cyprodinil** (Switch 62.5WG) | **Onions** (dry bulb, green onions, seed onions): Botrytis leaf blight, purple blotch, 7 days.[a] |
| **Dimethomorph** (Acrobat 50WP, Forum 4.18 SC) | **Bulb vegetables** (garlic, leek, onion, shallot); **cucurbits** (cantaloupe, chayote, Chinese wax gourd, citron melon, cucumber, gherkin, gourd, muskmelon, pumpkin, squash, watermelon, zucchini); **eggplant; leafy vegetables** (Brassica leafy green, endive, lettuce); **pepper; potato; tomato.** Read and follow label directions. |
| **Ethoprop** (Mocap) | **Beans** (snap and lima), **cabbage, corn** (sweet), **cucumber, potato, sweet potato**: for nematode control. Read and follow label directions. |
| **Famoxadone + cymoxanil** (Tanos) | **Cucurbits** (cantaloupe, cucumber, honeydew melon, muskmelon, pumpkin, summer squash, watermelon, winter squash): Alternaria leaf blight, anthracnose, bacterial fruit blotch, downy mildew, Phytophthora blight, 3 days.[a]<br>**Lettuce:** downy mildew, 3 days.[a]<br>**Pepper** (all varieties): bacterial soft rot, bacterial spot, Phytophthora blight (foliar and fruit phase only), 3 days.[a]<br>**Potato:** brown spot, early blight, late blight, 14 days.[a]<br>**Tomato:** anthracnose, bacterial spot, bacterial speck, buckeye rot (Phytophthora species), early blight, leaf mold, late blight, Septoria leaf spot, target spot, 3 days.[a] |
| **Fenamidone** (Reason 500SC) | **Bulb vegetables** (garlic, leek, onion, shallot): for control of downy mildew and purple blotch. Apply on 5- to 10-day intervals. Do not apply within 7 days of harvest.<br>**Cucurbits:** for control of Alternaria leaf spot and downy mildew. Apply on 5- to 10-day intervals. Do not apply within 14 days of harvest.<br>**Lettuce:** for control of downy mildew. Apply on 5- to 10-day intervals. Do not apply within 2 days of harvest.<br>**Potato and other tuberous and corm vegetables** (artichoke, canna, cassava, chayote, ginger, sweet potato, yam): for control of early blight, late blight, and white rust. Read and follow label directions. Do not apply within 14 days of harvest.<br>**Tomato:** for control of early blight, late blight, and Septoria leaf spot. Apply at 5- to 10-day intervals. Do not apply within 14 days of harvest. |
| **Fenamiphos** (Nemacur 15G) | **Brussels sprout, cabbage, eggplant, garlic, okra, pepper** (non-bell): for nematode control. Read and follow label directions. |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **Fludioxonil** (Maxim 4FS) | **Sweet corn:** seed treatment for seedborne and soilborne fungi causing seed decay, damping-off, and seedling blights. Read and follow label directions. |
| (Maxim) | **Potato:** potato seed protectant. Read and follow label directions. |
| **Fosetyl-AL** (Aliette) | **Broccoli, broccoli raab, Brussels sprout, cabbage, Chinese broccoli, Chinese cabbage** (bok choy and Napa), **Chinese mustard cabbage, cauliflower, collard, kale, kohlrabi, mustard greens, mustard spinach, rape greens:** downy mildew, 3 days.[a]<br>**Chinese waxgourd, citron melon, cucumber, gherkin, gourd** (edible), ***Momordica* spp., muskmelon, pumpkin, summer and winter squash, watermelon:** downy mildew, 0 days (12 hours).[a]<br>**Ginseng:** Phytophthora root rot, Alternaria leaf blight, 31 days.[a] Read and follow label directions.<br>**Leafy vegetables** (except Brassica vegetables): downy mildew, 3 days.[a]<br>**Onion** (dry bulb): downy mildew, 7 days.[a]<br>**Tomato:** Phytophthora root rot, damping-off *(Pythium* spp.). |
| **Iprodione**[c] (Rovral) | **Beans:**[d] gray mold *(Botrytis)*, white mold *(Sclerotinia)*.<br>**Broccoli:** blackleg.<br>**Carrot:** Alternaria blight, black crown rot, no more than 4 applications.<br>**Chinese mustard:** Alternaria leaf spot, no more than 4 applications.<br>**Garlic:** white rot, no more than 1 application.<br>**Lettuce:** lettuce drop and bottom rot, no more than 3 applications, 14 days.[a]<br>**Onion** (dry bulb): Botrytis leaf blight, Botrytis neck rot, and Alternaria purple blotch, no more than 5 applications.<br>**Potato:** early blight and white mold, no more than 4 applications, 14 days.[a]<br>The following crops may be rotated after harvest: **beans, broccoli, carrot, garlic, lettuce, onion** (dry bulb), **peanut, potato.**<br>The following crops may be rotated 1 month following the last iprodione application: **cotton, root crops, tomato**. Read and follow label directions. |
| **Mefenoxam** (Apron XL LS) | **Beets, carrot, legume vegetables, okra, spinach:** seed treatment for control of *Pythium* and *Phytophthora* causing damping-off, seed rot, and systemic downy mildew diseases. Read and follow label directions for these uses, as well as seed treatments for export. |
| (Ridomil Gold Bravo) | **Broccoli, Brussels sprout, cabbage, cauliflower:** downy mildew and Alternaria leaf spot, 7 days.[a] Read and follow label directions.<br>**Cucumber, melon, squash:** downy mildew, anthracnose, Cercospora leaf spot, gummy stem blight (black rot), leaf blight, and scab. Read and follow label directions.<br>**Onion:**[c] (dry bulb, seed, and green) downy mildew, Botrytis leaf blight (blast), and purple blotch; dry, 7 days,[a] and green, 21 days.[a] Read and follow label directions.<br>**Potato:** late blight and early blight, storage rots (Pythium leak; pink rot caused by *Phytophthora)*, 14 days.[a] Read and follow label directions. |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **Mefenoxam (cont.)** | |
| (Ridomil Gold Bravo) (cont.) | **Tomato:** late blight and early blight, Phytophthora fruit rot, gray leaf spot, gray leaf mold, Septoria leaf spot, anthracnose, Alternaria fruit rot (black mold), Rhizoctonia fruit rot, and Botrytis gray mold, 14 days.[a] Read and follow label directions. |
| (Ridomil Gold Copper) | **Carrot, radish:** diseases caused by oomycetes, 7 days.[a] Read and follow label directions.<br>**Cucurbits:** downy mildew, 5 days.[a] Read and follow label directions.<br>**Onion** (dry bulb, seed, and green), **garlic:** downy mildew, dry, 10 days,[a] and green, 7 days.[a] Read and follow label directions.<br>**Pepper:** Pythium damping-off, Phytophthora crown rot, 7 days.[a] Read and follow label directions.<br>**Potato:** late blight and early blight, storage rots (Pythium leak; pink rot caused by *Phytophthora)*, 7 days.[a] Read and follow label directions.<br>**Spinach:** white rust and downy mildew, 21 days.[a] Read and follow label directions.<br>**Tomato:** Phytophthora fruit rot, late blight, 14 days.[a] Read and follow label directions. |
| (Ridomil Gold EC) | **Asparagus:** Phytophthora crown and spear rot. Read and follow label directions.<br>**Beans** (all), **lentils, peas, soybeans** (edible): Pythium damping-off and root rot. When applied preplant and incorporated in the top 2 in. of soil with a surface application, or in a 7-in. band at planting. Read and follow label directions.<br>**Cole crops:** Pythium damping-off and Phytophthora basal stem rot. Surface applications may be broadcast at planting, incorporated into the upper 2 in. of soil. Seven-inch band applications are also labeled. Read and follow label directions.<br>**Cucurbits:** Pythium damping-off and cottony leak. Applications may be in a 7-in. band over the row at planting or broadcast. Broadcast applications should be incorporated into the top 2 in. of soil. Read and follow label directions.<br>**Lettuce** (head), **onion, spinach:** Pythium damping-off. Apply either broadcast or banded at planting. Read and follow label directions.<br>**Eggplant, pepper:** Pythium damping-off, Phytophthora crown rot, 7 days.[a]<br>**Root and tuber vegetables** (beet, carrot, radish, sweet potato): Read and follow label directions.<br>**Tomato:** Pythium damping-off, as well as Pythium and Phytophthora fruit and root rots. Apply either broadcast or banded immediately before or after planting. Incorporate with irrigation. Read and follow label directions. |
| (Ridomil Gold GR) | **Leafy vegetables** (excluding spinach), **lettuce** (head and leaf): Pythium damping-off. Applications may be made banded over the row or preplant incorporated. Read and follow label directions.<br>**Spinach:** Pythium damping-off, white rust *(Albugo occidentalis)*, and downy mildew. Applications may be made preplant incorporated or preemergence. Read and follow label directions.<br>**Tomato:** Pythium damping-off. Pythium and Phytophthora fruit and root rots, 7 days.[a] Read and follow label directions. |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **Mefenoxam (cont.)** (Ridomil Gold MZ) | **Cucumber, melon, summer squash:** downy mildew, 5 days.[a] Read and follow label directions.<br>**Onion** (dry bulb): downy mildew, 7 days.[a] Read and follow label directions.<br>**Potato:** late blight and early blight, storage rots (Pythium leak; Phytophthora pink rot), 14 days.[a] Read and follow label directions.<br>**Tomato:** late blight, 5 days.[a] Read and follow label directions. |
| (Ridomil Gold PC) | **Beans** (dry and green):[d] damping-off and seed and seedling rots caused by *Pythium* and *Rhizoctonia*. Apply 12 oz per 1,000 ft of row at planting time. Read and follow label directions. |
| **Metalaxyl** (Allegiance FL) | **Beets, carrot, cucumber, seed and pod vegetables, spinach, sweet corn, and popcorn:** seed treatment for the control of Pythium damping-off and in certain crops for early-season *Phytophthora* control. Read and follow label directions for these uses, as well as seed treatments for export use. |
| **Myclobutanil** (Nova) | **Asparagus:** for control of rusts. Begin applying to developing ferns after harvest has taken place. Repeat application on a schedule that does not exceed 14-day intervals. Apply with a spray adjuvant. Do not spray within 180 days of harvest.<br>**Beans** (snap): for control of rust and pot tip rot *(Rhizoctonia)*. Begin application when rust is first observed; continue on a 7- to 10-day schedule, 0 days.[a]<br>**Cucurbits:** for control of powdery mildew. Begin application at first sign of disease development and continue on a 7- to 10-day application schedule. Do not apply more than 1.5 lb product (0.6 lb active ingredient) per acre per crop per year. Application may be made up to and including the day of harvest. Read and follow label directions.<br>**Tomato:** for control of powdery mildew. Begin application at the first sign of disease, and continue application on a schedule that does not exceed 21-day intervals, 0 days.[a] Read and follow label directions carefully. |
| **Oxamyl** (Vydate L) | **Carrot, cucurbits, eggplant, pepper, potato, sweet potato:** for nematode control. Apply before or at planting. Apply in transplant water for pepper or as foliar spray for pepper and vine crops, 7 days.[a] Read and follow label directions. |
| **PCNB** (Terraclor) | *Field use*—**Beans** (dry, snap, succulent): protective fungicide for control of root and stem rot caused by *Rhizoctonia solani*. Spray planting furrow and covering soil at planting. Apply only at planting time and avoid spraying directly on seed. Read and follow label directions.<br>**Broccoli, Chinese broccoli, Brussels sprout, cabbage, Chinese cabbage** (tight-heading only), **cauliflower:** for control of clubroot and wirestem or black root. For effective control of clubroot, thoroughly mix Terraclor with the soil. Read and follow label directions. |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **PCNB (cont.)** | |
| (Terraclor) (cont.) | *Bedding plants*—**Beans, broccoli, Brussels sprout, cabbage, cauliflower, pepper, tomato:** soil drench to seedlings grown in containers or beds prior to transplanting for the control of root/stem rot and damping-off caused by *Rhizoctonia solani* and *Pellicularia filamentosa*. Read and follow label directions. |
| **Phosphorous acid** | |
| (Agri-Fos) | **Asparagus:** Phytophthora crown and spear rot, 0 days.[a]<br>**Brassicas:** downy mildew, 0 days.[a]<br>**Carrot:** Pythium and Phytophthora rot, 0 days.[a]<br>**Cucurbits:** Phytophthora blight, gummy stem blight, downy mildew, 0 days.[a]<br>**Eggplant:** gummy stem blight, Pythium rot, and Phytophthora rot, 0 days.[a]<br>**Ginseng:** Phytophthora root rot and foliar blight, 0 days.[a]<br>**Leafy vegetables** (amaranth, arugula, cardoon, celery, chervil, corn salad, endive, fennel, parsley, radicchio, rhubarb, spinach, Swiss chard): downy mildew, 0 days.[a]<br>**Legumes:** Pythium rot and Phytophthora rot, 0 days.[a]<br>**Okra:** Pythium rot and Phytophthora blight, 0 days.[a]<br>**Onion:** downy mildew, 0 days.[a]<br>**Potato, sweet potato, yams:** pink rot (*Phytophthora* spp.), Pythium leak (*Pythium* spp.), late blight, 0 days.[a]<br>**Tomato:** Late blight, 0 days.[a] |
| (Phostrol) | **Asparagus:** Phytophthora crown rot and spear rot, 0 days.[a]<br>**Brassicas:** downy mildew, 0 days.[a]<br>**Cucurbits:** downy mildew, Phytophthora blight, 0 days.[a]<br>**Ginseng:** Phytophthora root rot and foliar blight, 0 days.[a]<br>**Leafy vegetables** (except Brassica vegetables): downy mildew, 0 days.[a]<br>**Onions** (dry bulb): downy mildew, 0 days.[a]<br>**Peas:** downy mildew, Phytophthora disease, Pythium rot, 0 days.[a]<br>**Potatoes:** pink rot (*Phytophthora* spp.) and Pythium leak (*Pythium* spp.), 0 days.[a]<br>**Tomato:** Phytophthora root rot. |
| (ProPhyt) | **Brassicas:** downy mildew, 0 days.[a]<br>**Cucurbits:** downy mildew, 0 days.[a]<br>**Leafy vegetables** (lettuce, spinach): downy mildew, 0 days.[a]<br>**Legume vegetables:** downy mildew, 0 days.[a]<br>**Potato:** late blight, 0 days.[a]<br>**Tomato, tomatillo:** late blight, 0 days.[a] |
| **Propamocarb hydrochloride** | |
| (Previcur Flex) | **Curcurbits:** for control of downy mildew. Begin foliar applications when conditions are favorable for disease development but before infection. Continue on 7- to 14-day intervals. Do not apply within 2 days of harvest.<br>**Lettuce:** for control of downy mildew. Start applications before infection and continue on 7- to 10-day intervals. Do not apply within 2 days of harvest.<br>**Peppers:** for control of *Pythium* spp. and *Phytophthora* spp. Read and follow label directions. |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **Propamocarb hydrochloride (cont.)** (Previcur Flex) (cont.) | **Potato:** for control of early blight and late blight. Do not apply within 14 days of harvest. **Tomatoes:** for control of late blight. Read and follow label directions. Do not apply within 5 days of harvest. |
| **Propiconazole** (Tilt) | **Celery:** early blight *(Cercospora)*, late blight *(Septoria)*, 14 days.[a] Read and follow label directions. **Corn** (sweet and pop): Helminthosporium leaf blights, rusts, gray leaf spot, and eyespot. Sweet corn, 14 days.[a, b] Do not apply more than 16 fl oz per acre. Do not apply to popcorn after silking. Do not harvest for forage within 14 days of application for sweet corn or 30 days for popcorn. Read and follow label directions. |
| **Pyraclostrobin** (Cabrio, Headline) | **Brassica head and stem** (broccoli, Brussels sprout, cabbage, Chinese cabbage, cauliflower, kohlrabi), **Brassica leafy green** (broccoli raab, Chinese cabbage, collard, kale, mustard green, rape green), **bulb vegetables** (onion, garlic, leak, shallot), **cucurbits** (chayote, Chinese waxgourd, citron melon, cucumber, gherkin, gourd, *Momordica* spp., muskmelon, pumpkin, summer squash, watermelon, winter squash), **fruiting vegetables** (eggplant, ground cherry, pepino, pepper, tomatillo, tomato), **leaf vegetables** (except brassicas), leaves of root and tuber vegetables (except sugarbeet), **root vegetables** (black salsify, carrot, celeriac, chervil, chicory, edible burdock, garden beet, ginseng, horseradish, Oriental radish, parsley, parsnip, radish, rutabaga, Spanish salsify, skirret, turnip), **tuber and corm vegetables** (arracacha, arrowroot, cassava, Chinese artichoke, chufa, dasheen, edible canna, Jerusalem artichoke, leren, potato, sweet potato, true yam, turmeric, yam bean). |
| (Pristine) | **Beans** (dry beans): Alternaria leaf and pod spot, anthracnose, Assochyta blight, Botrytis gray mold, Cercospora leaf spot, downy mildew, Mycosphaerella blight, powdery mildew, rust, Septoria leaf spot, white mold, 21 days.[a] **Bulb vegetables** (garlic, leek, onion): Botrytis leaf blight, downy mildew, purple blotch, Stemphylium leaf blight and stalk rot, 7 days.[a] **Carrot:** Alternaria leaf spot, Cercospora leaf spot, powdery mildew, southern root rot *(Sclerotium rolfsii)*, 0 days.[a] **Cucurbits** (chayote, Chinese waxgourd, citron melon, cucumber, gherkin, gourds, *Momordica* spp., muskmelon, pumpkin, summer squash, winter squash): Alternaria blight, anthracnose, Cercospora leaf spot, downy mildew, gummy stem blight, powdery mildew, 0 days.[a] |
| **Pyrimethanil** (Scala SC) | **Bulb vegetables** (garlic, leek, onion, shallot): for control of Botrytis leaf blight and neck rot and purple blotch. Apply on 7- to 14-day intervals. Do not apply within 7 days of harvest. **Potato and other tuberous and corm vegetables** (arrachata, arrowroot, artichoke, canna, cassava, chayote, ginger, yam). Read and follow label directions. Do not apply within 7 days of harvest. |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **Pyrimethanil (cont.)** (Scala SC) (cont.) | **Tomatoes:** for control of early blight and gray mold. Apply on 7- to 14-day intervals. Do not apply within 1 day of harvest. |
| **Streptomycin** | **Beans:** halo blight, seed treatment.<br>**Pepper, tomato:** apply at 2-leaf stage (200-ppm spray).<br>**Potato:** seed-piece treatment only (100-ppm dip or dust). Soak cut seed pieces less than 30 min. Do not use treated seed for food or feed. Read and follow label directions. |
| **Sulfur** | Exempt when used with good agricultural practices. See label. |
| **Terbufos** (Counter 15G) | **Corn** (sweet and pop): apply in band or furrow at planting. Read and follow label directions. |
| **Thiabendazole** (Mertect 340F) | **Carrot:** storage rot (gray mold and white mold) control.<br>**Sweet potato:** treatment of seed against black rot, scurf, and foot rot. Do not use treated roots for food or feed.<br>**Potato:** seed-piece treatment to control Fusarium tuber rot. Do not treat seed potatoes after cutting. Read and follow label directions. |
| **Thiophanate-methyl** (Topsin M 70W, Topsin M WSB) | **Beans:** white mold and gray mold. Snap or dry beans, 14 days[a]; lima, 28 days.[a]<br>**Cucurbits:** anthracnose, gummy stem blight, powdery mildew, and target spot, 0 days.[a]<br>**Onion:** white rot. Apply in-furrow at planting. Read and follow label directions. |
| **Thiram** | **Beans, beet, broccoli, Brussels sprout, cabbage, cantaloupe, carrot, castor beans, cauliflower, collard, corn** (sweet), **cucumber, eggplant, endive, kale, kohlrabi, lettuce, mustard, okra, onion, peas, pepper, pumpkin, radish, spinach, squash, Swiss chard, tomato, turnip, watermelon:** seed treatment. WARNING: Do not use treated seed for food, feed, or oil.<br>**Onion:** furrow treatment.<br>**Tomato:** for leaf spots and fruit rot, 0 days.[a] Read and follow label directions. |
| **Trifloxystrobin** (Flint) | **Cucurbits:** for control of downy mildew and powdery mildew, 0 days.[a] Follow label directions carefully.<br>**Eggplant, groundcherry, pepino, pepper, tomatillo, tomato:** powdery mildew, early blight, gray leaf spot, and late blight, 3 days.[a] Follow label directions. |
| (Gem) | **Potato:** early blight, late blight, 7 days.[a] |

**Table 2. Label information on fungicides and nematicides of less general use (cont.)**

| Fungicide | Crops and use restrictions |
|---|---|
| **Triflumizole** (Procure 50WS) | **Cucurbits** (cucumber, melons, summer squash, watermelon): for control of Alternaria leaf spot, Cercospora leaf spot, downy mildew, and fruit and stem rot, 5 days.[a] Begin applications when plants are in the 2-leaf stage and repeat at 7- to 10-day intervals when environmental conditions are conducive for disease development. |
| **Triphenyltin hydroxide** (Super Tin) | **Potato:** for control of early blight and late blight, 3 days.[a] Begin applications at the first sign of disease or when late blight is reported in the area. |
| **Vinclozolin** (Ronilan) | **Beans** (snap, common, and lima): gray mold, white mold, 14 days.[a] Do not make more than 2 applications per season or more than 2 lb of the product per season. Read and follow label directions.<br>**Lettuce** (head or leaf): Sclerotinia drop, 28 days.[a] No more than 6 lb/A/season.<br>**Onion** (dry): white rot, Botrytis blight, neck rot, 18 days.[a] No more than 10 lb/A/season. |
| **Ziram** (Ziram 76DF) | **Tomato** (not cherry tomato): anthracnose, early blight, Septoria leaf spot, 7 days.[a] Do not apply more than 24 lb of product per acre per crop cycle. Read and follow label directions. |
| **Zoxamide** (Gavel 75DF) | **Tomato** (not cherry tomato): anthracnose, early blight, Septoria leaf spot, 7 days.[a] Do not apply more than 24 lb of product per acre per crop cycle. Read and follow label directions.<br>**Tomato:** for control of buckeye rot, early blight, gray leaf spot, late blight, leaf mold, Septoria leaf spot, bacterial speck, bacterial spot, 5 days.[a] Start applications when seedlings emerge or transplants are set and repeat at 7- to 10-day intervals. For bacterial diseases, use a full rate of fixed-copper fungicide in tank-mixed combinations with a full rate of Gavel 75DF. Follow label directions carefully. |

[a]Number of days between last application and harvest.
[b]There are many other copper materials, but these are most widely available and labeled for use on vegetable crops. Exempt from tolerance if used with good agricultural practices; not exempt if used at the time of harvest or after harvest. See label.
[c]Phytotoxicity to crop or follow-up crop. See label.
[d]Do not feed treated tops or forage to livestock.

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006**

| Vegetable and disease | Disease-management practices |
|---|---|
| **ASPARAGUS** | |
| Fusarium crown and root rot | Obtain crowns from a reliable source. Avoid fields with a history of crown and root rot. Avoid excessive cutting. Avoid acidic (low-pH) and poorly drained soils. Dip roots in a solution of Manzate 75DF at 1 lb per 100 gallons or Manex II at 0.8 qt per 100 gallons. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **ASPARAGUS (CONT.)** | |
| Phytophthora crown and spear rot | Use Ridomil Gold EC over bed. Apply 30 to 60 days before harvest, with a second application just before harvest, 1-day preharvest interval. Apply Aliette WDG once per season, 110-day preharvest interval. Apply Agri-Fos to ferns that have 2 to 3 in. of new growth. Start applications when conditions are cool and wet. Apply Phostrol; read and follow label directions. |
| Rust, Cercospora, and other leaf and branchlet blights | Grow rust-resistant varieties. Apply mancozeb (at 7- to 10-day intervals) or Nova (at 14-day intervals) to nonharvested fields up to August 15 and to harvested fields only after harvest. Control is needed in 1- and 2-year beds, even with resistant varieties. |
| **BEANS (SNAP, DRY WAX, AND LIMA)** | |
| Most diseases | When possible, use rotations of 2 to 3 years or longer between bean crops and practice strict sanitation. |
| Seed decay, damping-off, seedborne stem blights, and root rots | Plant only western-grown, certified pathogen-free seed in a seedbed that is warm (60° to 65°F), well prepared, and well drained. Treat seed with Allegiance FL, Apron XL plus thiram, captan, Dynasty, or Protégé and an insecticide. In-furrow sprays of Ridomil Gold (EC or PC) or seed treatment with Apron XL may be helpful for early-season root-rot control. Ridomil Gold EC or PCNB may be used to help control *Rhizoctonia*. |
| Root rots | Pythium root rot can be controlled using Ridomil Gold EC as a band or furrow treatment at planting. Maintain optimal soil fertility. Utilize rotations of at least 2 to 3 years with other crops. |
| Bacterial blights | Plant only western-grown, certified pathogen-free seed. Utilize crop rotations of 2 to 3 years. Avoid cultivating when beans are wet. Field applications of 2 to 4 lb of fixed copper (for example, Kocide 101) per acre provide good control of brown spot and halo blight but only moderate control of common blight. Do *not* use copper on fresh-market lima beans. Streptomycin can be used as a seed treatment to control halo blight. |
| Asian soybean rust | Apply Amistar or Headline to control Asian soybean rust. Read and follow label directions. |
| Rust, anthracnose, and other fungal leaf, pod, and stem diseases | Utilize crop rotations of 2 to 3 years. Apply Bravo at 7- to 10-day intervals starting when disease first appears. Apply Nova at 7- to 10-day intervals to control rust and pot tip rot *(Rhizoctonia)*. Start the application when the disease first appears. Read and follow label directions. Apply Amistar, Headline, Endura, or Pristine to control anthracnose, Ascochyta blight, Mycosphaerella blight, and rust (dry beans only). Read and follow label directions. Use Quadris Opti to control anthracnose, Alternaria leaf spot, Ascochyta leaf spot, rust, and web blight *(Rhizoctonia solani)*. Follow label directions. Rust-resistant varieties are available for some types of beans. Sulfur also may be used but may be phytotoxic at high temperatures. Bravo Weather Stik is used to control phakospora rust. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **BEANS (SNAP, DRY WAX, AND LIMA) (CONT.)** | |
| Gray mold | Apply Bravo, Rovral, or Topsin M at 25% bloom, and repeat at full bloom. Thorough coverage of blossoms is essential. |
| White mold | Apply Endura, Rovral, or Topsin M at 25% bloom, and repeat at full bloom. |
| Mosaic virus diseases | Plant varieties with resistance to bean common mosaic, NY15 strain of common mosaic, and bean yellow mosaic. Avoid planting near clovers, birdsfoot trefoil, gladiolus, and so forth. |
| Soybean cyst nematode | Rotate at least 2 to 3 years with corn, small grains, alfalfa, or other nonhost crop. Do *not* include soybeans in the rotation. Temik may be used on dry beans. |
| Root-knot and lesion nematodes | Use Vydate L, methyl bromide, or sodium methyl dithiocarbomate. Follow label directions carefully. |
| **BEET (GARDEN), SWISS CHARD** | |
| Seed rot, damping-off, and seedborne leaf spot | Sow in a well-prepared seedbed. Treat seed with Apron XL or Allegiance FL (for *Pythium),* captan, or thiram. Make sure boron levels are adequate. Several soluble boron formulations are available. |
| Cercospora leaf spot | Apply Amistar, Bravo, Cabrio, or fixed copper weekly, or Quadris at 10- to 14-day intervals alternating with other fungicides, at the first sign of disease. Separate new from old plantings. |
| **CARROT, PARSNIP** | |
| Seed rot, damping-off | Treat seed with captan or thiram. Plant in well-drained seedbed. Avoid overwatering. Apron XL and Allegiance FL can be used to control Pythium damping-off on carrot. |
| Cercospora leaf spot, Alternaria leaf blight | Use a crop rotation of 3 to 4 years. Apply Amistar, Bravo, Cabrio, Endura, Pristine, Rovral, Quadris, or Quadris Opti. Start when disease first appears and repeat as needed. |
| White mold | Use a crop rotation of 3 to 4 years. |
| Aster yellows | Use insecticides to control leafhoppers that transmit the mycoplasma. Excellent early-season leafhopper control is essential. Control must occur before leafhoppers feed. |
| Powdery mildew | Apply Pristine, a total of 6 applications per season. Apply Amistar; read and follow label directions. |
| Root-knot nematode | Fumigate mineral soils with Telone II or Vapam; or practice a 3-year rotation with corn or other nonhost crops. Control broadleaf weed hosts. Vydate L (carrot only) may be applied at planting in-furrow or broadcast 1 week before planting. |
| Parsnip canker, leaf spot, and mildew | Spray with fixed copper 3 times at 10-day intervals at first sign of disease. Ridge soil over the shoulders to prevent canker infections. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **CELERY, PARSLEY** | |
| Seed rot, damping-off, and seedborne leaf blights | Treat seed with hot water, then captan or thiram. If damping-off starts, spray 2 to 3 times at 5- to 7-day intervals with Bravo (celery only) or fixed copper. Seed 2 to 3 years old is free of late blight. |
| Leaf blights and spots (celery only) | Spray Bravo at 7- to 10-day intervals or Amistar, Quadris, Quadris Opti at 10- to 14-day intervals. Alternate application of Quadris with other fungicides. |
| Leaf spots and powdery mildew (parsnip only) | Apply Cabrio. Read and follow label directions. |
| Aster yellows and root-knot nematode | See the section on carrot and parsnip. |
| **CORN (SWEET AND POP)** | |
| Seed rot, seedling blights, and seedborne diseases | Plant seed treated with captan, Dynasty, Protégé, or thiram plus an insecticide. Plant shallow in warm, well-drained soil. |
| Goss's bacterial wilt | Use 2- to 3-year crop rotations when using susceptible corn (dent or sweet) varieties. |
| Stewart's disease | Plant resistant varieties, or control corn flea beetles on young plants with an insecticide. |
| Smut | Plant tolerant varieties. Control corn borers as first tassels appear. |
| Maize dwarf mosaic, chlorotic dwarf, and wheat streak mosaic | Control johnsongrass and volunteer wheat. Plant resistant or tolerant varieties. |
| Helminthosporium leaf blights and anthracnose leaf blight | Plant resistant varieties. Spray Amistar, Bravo, mancozeb, maneb, Quadris, Quilt, Tanos, or Tilt when disease first appears. Crop rotation and clean tillage help reduce disease risk. Follow label directions carefully. |
| Rusts | Plant resistant varieties. Spray Amistar, Bravo, mancozeb, Quadris, Quilt, or Tilt at the first sign of disease. |
| Virus diseases | Plant resistant or tolerant varieties. Control johnsongrass and volunteer wheat. |
| Nematodes | Apply Counter or Mocap (sweet corn only) at planting time. |
| **CRUCIFER CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, CHINESE CABBAGE, COLLARD, KALE, KOHLRABI, MUSTARD, RADISH, RUTABAGA)** | |
| Seed rot, damping-off | Sow only western-grown, hot water–treated seed. Seed also should be treated with thiram or captan. Place seedbeds where no crucifer has grown for 4 years or more and where water will not drain from fields recently planted to crucifers. Ridomil Gold EC applied at planting time controls Pythium damping-off and Phytophthora basal stem rot. |
| Alternaria leaf spot | Use a crop rotation of 3 to 4 years. Apply Amistar, Bravo, Endura, maneb, manex, or Quadris. Follow label directions. Apply Cabrio (root crucifers only). Read and follow label directions. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **CRUCIFER CROPS (BROCCOLI, BRUSSELS SPROUT, CABBAGE, CAULIFLOWER, CHINESE CABBAGE, COLLARD, KALE, KOHLRABI, MUSTARD, RADISH, RUTABAGA) (CONT.)** | |
| Wirestem *(Rhizoctonia)* | Incorporate PCNB-captan in the upper 3 in. of soil before planting, or drench after planting. Apply Amistar; read and follow label directions. |
| Clubroot | Use only healthy transplants. Avoid soils with a history of clubroot. If clubroot is present, adjust soil pH to 7.2 with hydrated lime. Rotate out of cruciferous crops for 7 years. Apply PCNB (Terraclor 75WP) in transplant water or as a band or broadcast application. |
| Black rot and blackleg | Use certified, hot water–treated seed. Use a crop rotation of 3 to 4 years. Use care in selecting plant bed sites. Be sure no drainage occurs to the seedbed from old plantings. Control wild mustard and other cruciferous weeds. Purchase only certified, disease-free transplants, and do not dip before planting. Sprays of fixed copper may help control black rot. Rovral may be used to control blackleg on broccoli. Bravo applied to control downy mildew also may help control blackleg. Some cabbage varieties resistant to black rot are available. Losses are generally lower where direct seeding is used. |
| Downy mildew | Rotate with noncruciferous crops for 3 years. Plant disease-resistant varieties when available. Apply Acrobat, Aliette, Amistar, Bravo, Forum, maneb, Ridomil Gold Bravo, Phostrol, ProPhyt, or Quadris. Apply Agri-Fos when conditions favor disease development. |
| Powdery mildew | Apply Microthiol Special at early-leaf stage and repeat at 14-day intervals as needed. Read and follow label directions. Apply Endura at 7- to 14-day intervals to control powdery mildew. |
| Internal tip burn | Plant resistant varieties. Avoid overfertilizing, especially with nitrogen. |
| Fusarium yellows | Plant only yellows-resistant varieties. |
| Radish black root | Plant resistant varieties. Avoid planting radishes in severely infested soil. |
| Rhizoctonia bottom rust | Apply Amistar or Endura at 7- to 14-day intervals to control Rhizoctonia bottom rust. |
| Sclerotinia stem rot | Apply Endura at 7- to 14-day intervals to control Sclerotinia stem rot. |
| White rust | Apply Amistar or Quadris. Follow label directions. Apply Cabrio (root crucifers only). Read and follow label directions. |
| Nematodes | Mocap (cabbage only) or Nemacur (Brussels sprout and cabbage only) may be applied at planting. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **CUCURBITS (CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON)** | |
| General | Use a crop rotation of 3 to 4 years. Grow resistant varieties whenever possible. |
| Seed rot, damping-off, and seedborne diseases | Plant only certified, western-grown seed treated with captan or thiram. Ridomil Gold EC can be used as a broadcast or banded soil application. Seed treatment with Apron XL LS prevents seedling damping-off caused by *Phytophthora* and *Pythium*. Seed treatment with Protégé controls seedborne and soilborne fungi in cucumber. |
| Angular leaf spot | Practice crop rotations of 3 to 4 years. Resistant cucumber varieties are available. Apply fixed-copper sprays in combination with Bravo. Start applications early in the season. |
| Bacterial wilt | Provide season-long control of striped and spotted cucumber beetles. Start as the plants begin to emerge. Planting-time treatment with Furadan provides moderate control for 3 to 4 weeks. Supplemental insecticide use is necessary. |
| Bacterial leaf and fruit spot | Grow certified pathogen-free seed. Practice at least a 2-year rotation with noncucurbit crops. Copper sprays applied during early formation and expansion of fruit may result in lower incidence of disease. |
| Bacterial fruit blotch | Plant pathogen-free seed. Practice at least a 2-year rotation with noncucurbit crops. Application of copper hydroxide or Tanos could help suppress disease development. |
| Alternaria leaf blight | Practice a 3- to 4-year rotation. Apply Amistar, Bravo, Cabrio, Gavel, mancozeb, Pristine, Quadris, Reason, or Tanos at 7- to 10-day intervals, beginning with the first sign of disease. |
| Anthracnose, scab, blossom blights, gummy stem blight, and black rot | Grow resistant varieties when possible. Spray with Amistar, Bravo, Cabrio, mancozeb, maneb, Pristine, Quadris Opti, Tanos, or Topsin M. Quadris can be used for anthracnose and gummy stem blight. Follow label directions. Start when vines begin to run. |
| Downy mildew | Practice a 2- to 3-year rotation. Grow resistant varieties when possible. Maintain ample but not excessive nitrogen fertility. Apply Acrobat, Agri-Fos, Aliette, Amistar, Bravo, copper, Curzate, Flint, Forum, Gavel, mancozeb, maneb, manex, Phostrol, Previcur, Pristine, ProPhyt, Quadris, Quadris Opti, Ranman, Reason, or Tanos weekly. Ridomil Gold Bravo provides excellent control of downy mildew. Follow label directions. |
| Fusarium wilt | Grow resistant varieties. |
| Mirodochium blight | Practice a 2- to 3-year rotation with noncucurbit crops. Apply Bravo, Cabrio, or mancozeb at 10- to 14-day intervals, beginning when vines form a complete canopy within rows. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **CUCURBITS (CUCUMBER, MUSKMELON OR CANTALOUPE, PUMPKIN, SQUASH, WATERMELON) (CONT.)** | |
| Phytophthora blight and root rot | Use a crop rotation of at least 3 years with noncucurbit crops. Do not include peppers, eggplants, and tomatoes in the crop rotation. Avoid fields that are poorly drained and have a history of the disease. Practices aimed at avoiding standing water in the field will reduce the incidence of disease. Applying Acrobat, Agri-Fos, Bravo, fixed copper, Forum, mancozeb, Phostrol, Pristine, Ranman, or Tanos may also reduce incidence of disease. |
| Powdery mildew | Apply Amistar, Bravo, Cabrio, Flint, Nova, Pristine, Procure, or Quadris. Apply Bravo when plants are in the first-true-leaf stage or when conditions are favorable for disease development. Quadris is applied on a one-to-one alternation with a fungicide having a different mode of action. Where Benlate is applied to control other diseases, powdery mildew is controlled under moderate disease pressure. Plant resistant varieties where possible. |
| Mosaic viruses | Control aphids and beetles in the field. Eliminate broadleaf weeds around field borders before plant establishment. Plant only mosaic-resistant cucumbers. |
| Root-knot nematode | Fumigate with Telone C-17, Telone II, or Vapam in the fall before planting; or use Furadan or Vydate L at planting. |
| **EGGPLANT** | |
| Seed rot, damping-off, and seedborne diseases | Plant hot water–treated seed when possible. Treat the seed with captan or thiram. Ridomil Gold EC may be used for Pythium damping-off. |
| Anthracnose | Apply Amistar, Cabrio, or Quadris. Follow label directions. |
| Phomopsis blight, Alternaria leaf spot, Cercospora leaf spot, and anthracnose | Follow good sanitary practices. Use a crop rotation of 2 to 3 years. Avoid bruising fruit; handle carefully at all times. Apply maneb at 7- to 10-day intervals, beginning at first fruit cluster. |
| Verticillium wilt and nematodes | Avoid fields with a history of Verticillium wilt. Rotate with small grains where possible. Fumigate the soil with Vapam or methyl bromide plus chloropicrin. Planting under a black plastic mulch helps reduce disease severity. Vydate L controls nematodes. |
| **HORSERADISH** | |
| Leaf spots (*Alternaria* and *Cercospora*) White rust | Apply Cabrio or Quadris at the first sign of disease. Read and follow label directions. Practice a 2-year field rotation with any other crop. Apply Quadris, Ridomil Gold EC, or Ridomil Gold WSP. Read and follow label directions. |
| Brittle root | Plant clean sets. Control leafhoppers that spread the disease agent. |
| **LETTUCE, ENDIVE, ESCAROLE** | |
| Seed rot, damping-off, and gray mold | Treat seed with captan or thiram. Ridomil Gold (EC or GR) as a soil application at seeding controls Pythium damping-off on head lettuce. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **LETTUCE, ENDIVE, ESCAROLE (CONT.)** | |
| Downy mildew | Apply Acrobat, Agri-Fos, Amistar, Forum, Phostrol, Previcur, ProPhyt, Reason, or Tanos. Read and follow label directions. |
| Powdery mildew | Apply Amistar or Quadris at the first sign of disease. Read and follow label directions. |
| Rhizoctonia bottom rot, Sclerotinia drop, and gray mold | Avoid wet fields with a history of disease. Plant on raised beds, and deep-plow when possible. Apply Amistar, Endura, Quadris, Ronilan, or Rovral at the 3-leaf stage and again 10 and 20 days later. Use 100 gallons of water carrier per acre. |
| Aster yellows and mosaic viruses | Control leafhoppers and aphids throughout the season. Early-season control is most important. |
| Nematodes | Apply Telone C-17, Telone II, or Vapam in the field in the fall before planting. In greenhouses, steaming the soil provides control. |
| **MINT (PEPPERMINT AND SPEARMINT)** | |
| Rust, Septoria leaf spot | Apply Amistar, Bravo, Echo, Quadris, or Terranil. Begin treatment when plants are 4 to 6 in. Repeat spraying at 7- to 10-day intervals for a total of 3 sprays, 80-day preharvest interval. |
| Powdery mildew | Apply Amistar. Read and follow label directions. |
| Verticillium wilt | Practice 3- to 4-year crop rotation. Plant wilt-resistant varieties. |
| **OKRA** | |
| Seed rot and damping-off | Treat seed with captan or thiram plus Apron XL LS. Plant in warm, well-drained soil. Apron XL LS or Allegiance FL can be used to control Pythium damping-off. |
| Fusarium and Verticillium wilts | Fumigate soil with Vapam or methyl bromide plus chloropicrin. |
| **ONIONS, GARLIC, LEEK, CHIVES, SHALLOT** | |
| Smut, seed rot, and damping-off | Treat the seed with captan or thiram. Use Methocel sticker to pellet the seed with fungicide. Use 1⅓ lb of active ingredient to 20 lb of seed for set onions and 6 lb of active ingredient to 8 lb of seed for bulb onions. Mancozeb or Ridomil Gold EC may be used as an in-furrow drench at planting. |
| Alternaria purple blotch, Botrytis neck rot, and downy mildew | Apply Amistar, Bravo, Cabrio, Endura, mancozeb (dry onions only), maneb, Pristine, Quadris, Quadris Opti, Reason, Rovral, Scala, or Switch. Begin spraying when the disease first appears and continue until harvest. Use Ridomil Gold Bravo or Ridomil Gold MZ (dry onions only) when downy mildew appears. |
| Downy mildew | Apply Acrobat, Agri-Fos, Amistar, Cabrio, Forum, Phostrol, ProPhyt, or Quadris Opti at first sign of disease. Apply Pristine at 7-day intervals. Read and follow label directions. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **ONIONS, GARLIC, LEEK, CHIVES, SHALLOT (CONT.)** | |
| Fusarium basal rot | Avoid heavily infested fields. Grow resistant varieties. Cure bulbs rapidly and properly. |
| White rot of garlic | Apply Amistar; read and follow label directions. Apply Rovral on cloves and in-furrow covering soil. Plant disease-free cloves in well-drained soil. |
| Storage decays | Maintain excellent control of leaf diseases in the field. Maintain dry storage conditions. |
| Yellow dwarf | Control aphids. Keep old and new plantings as far apart as possible. Destroy volunteer onions. |
| Bulb and stem nematode and root-knot nematode | Fumigate with Telone C-17, Telone II, or Vapam. Eradicate volunteer plants from fields with a history of bulb and stem nematode. |
| **PEAS** | |
| Seed rot and seedling and seedborne diseases | Plant western-grown seed treated with captan, Dynasty, or thiram and Apron XL LS plus an insecticide. Graphite at 1 oz per bushel may be added to reduce friction in the drill. |
| Root rots | Rotate fields with a history of root rot for at least 4 to 5 years. Include a crop of oats (green manure or full-season crop) the year before planting peas. |
| Fusarium wilt | Grow resistant varieties. Plant as early as possible in well-fertilized and well-drained soil. Rotate 4 or more years. |
| Powdery mildew | Apply sulfur dust or spray when mildew first appears and temperatures are less than 80°F. Two applications, a week apart, provide good control. Apply Amistar; read and follow label directions. Plant resistant varieties. |
| **PEPPER** | |
| Seed rot, damping-off, and seedborne diseases | Use only western-grown seed and treat with hot water or a household bleach (for example, Clorox) soak. The bleach soak helps control seedborne bacterial spot. Using 1 part bleach to 3 parts water, soak 1 minute. Use 1 gallon of fresh solution to 1 lb of seed. Rinse thoroughly before treating with captan or thiram seed protectant. Ridomil Gold EC may be used to control Pythium damping-off. |
| Bacterial spot | Plant disease-free seed or transplants. Use crop rotations of 2 to 3 years, excluding tomatoes. Control broadleaf weeds in and around field borders. Apply fixed copper plus streptomycin (200 ppm) to seedlings. After transplanting, apply fixed copper at 5- to 7-day intervals. The addition of maneb to the copper can increase the effectiveness of the application. Application of Tanos suppresses development of bacterial spot. Purchase only certified, disease-free transplants. Maintain a high, balanced level of soil fertility. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **PEPPER (CONT.)** | |
| Anthracnose, Cercospora leaf spot, other fungal leaf spots, and fruit rots | Use pathogen-free seed. Practice 3-year crop rotation. Burn or plow down crop refuse after harvest. Apply Amistar, Flint, maneb, manex, Quadris, or Tanos when disease first appears. |
| Blossom end rot | Avoid drastic fluctuation in moisture. Mulching plants may help. Avoid excessive nitrogen or potassium fertilization. Maintain pH and calcium levels in desired range. Choose varieties that are less susceptible. |
| Phytophthora blight | Use resistant varieties. Plant on raised beds in well-drained soil. Treat soil with Ridomil Gold EC. Rotate to nonsolanaceous crops for 3 to 4 years. Avoid waterlogged root zones throughout the season. Water management is very important in phytophthora control. Apply Acrobat or Forum to control Phytophthora blight. Apply Tanos prior to disease development; read and follow label directions. Apply Phostrol; read and follow label directions. |
| Powdery mildew | Apply Amistar, Cabrio, or Flint at the first sign of disease. |
| Verticillium wilt | Fumigate soil with Vapam or methyl bromide plus chloropicrin. |
| Viral diseases | Grow resistant varieties. Control aphids that transmit viruses. Eliminate broadleaf weeds within 150 ft of fields before crop is established. Plant only healthy transplants. |
| Root-knot nematode | Add Vydate L to transplant water and supplement with foliar applications. Follow label directions. Use methyl bromide if nematode populations are high. |
| **POTATO (IRISH)** | |
| General | Purchase only certified seed tubers. Seed-production fields should be inspected for viral, nematode, and fungal disease problems. Good sanitation and seed-handling practices reduce losses. |
| Seed-piece decay, seedborne diseases | Plant whole-seed tubers or cut-seed tubers that have been stored under conditions for rapid healing of cut surfaces. Treat seed with captan, mancozeb, maneb, or TOPS 2.5D. Keep seed storage at about 40°F during the winter. In the spring, warm the seed to 65° to 70°F for 2 to 3 weeks before cutting. |
| Scab | Plant resistant varieties. Practice a 3- to 4-year rotation schedule. Do *not* apply manure or other organic matter immediately before the potato crop. Maintain acidic soil. |
| Early blight | Apply Amistar, Bravo, Echo, Endura, Gavel, Gem, Headline, mancozeb, maneb, Previcur, Quadris, Quadris Opti, Reason, Rovral, Scala, Super Tin, Tanos, or Terranil. Begin application of fungicides at the first sign of disease. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **POTATO (IRISH) (CONT.)** | |
| Late blight | Destroy all potato cull piles. Apply Acrobat MZ, Amistar, Bravo, Curzate, Echo, Forum, Gavel, Gem, Headline, mancozeb, Phostrol, Previcur, ProPhyt, Quadris, Quadris Opti, Ranman, Reason, Ridomil Gold Bravo, Ridomil Gold MZ, Super Tin, Tanos, or Terranil at the first sign of disease. Apply Agri-Fos at first sign of disease, at 5- to 14-day intervals. Avoid bruising tubers. |
| Rhizoctonia | Avoid infested fields and plant uncontaminated seed tubers. Practice at least a 4-year rotation. Avoid deep planting. |
| Verticillium wilt | Practice at least a 2-year crop rotation and use only seed free of *Verticillium*. Control root-knot and root-lesion nematodes. Soil fumigation with Vapam may be practical. |
| Storage rots | Store healthy, sound, unbruised mature potatoes. Maintain a proper storage environment. Apply Mertect 340-F as a spray to unwashed tubers before storage to help control Fusarium dry rot. |
| Viral diseases and purple-top wilt (Aster yellows) | Plant only certified seed tubers. Control aphids and leafhoppers with insecticides. Practice clean cultivation. Rogue first-infected plants, including tubers. |
| Nematodes | Where soil samples indicate damaging levels of nematodes, apply Vydate L, methyl bromide, or sodium methyl dithiocarbomate, or fumigate with Telone C-17 or Vapam. |
| **RHUBARB (GREENHOUSE ONLY)** | |
| Leaf rot | Remove older, yellowed leaves or leaves with lesions in the fall. Fertilize in fall for growth in spring. |
| Crown and root rots | Use disease-free plants. Plant only in well-drained soil. Maintain optimal soil fertility. Drench the crowns with fixed copper at 3 lb per acre in the early spring and after harvest if crown rot is a problem. |
| **SPINACH** | |
| Seed rot and damping-off | Treat seed with captan or thiram. Apply Ridomil Gold EC for Pythium damping-off. |
| Downy mildew and white rust | Grow downy mildew–resistant varieties. Apply Actigard, Aliette, Amistar, copper, ProPhyt, or Quadris as a foliar spray when conditions favor disease development. A soil application of Ridomil Gold EC can also help control downy mildew and white rust. Ridomil Gold Copper can be used to control these diseases. There is a 21-day preharvest interval for both Ridomil Gold products. Read and follow label directions. Apply Agri-Fos at 7- to 10-day intervals. |
| Cucumber mosaic virus or blight | Grow tolerant varieties. Control aphids that spread the virus. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **SWEET POTATO** | |
| Black rot, root rot, Fusarium wilt, and scurf | Grow resistant varieties. Use clean soil in plant beds and maintain a temperature of 80° to 85°F. Plant disease-free roots and use crop rotations of 3 to 4 years. Dip the roots or sprouts in Mertect 340-F. |
| Storage rots | Fumigate storage crates and houses with formaldehyde. Cure and store only healthy, blemish-free roots. |
| Nematodes | Plant resistant varieties. Practice crop rotation. Mocap or Vydate L may be used for chemical control; or fumigate with methyl bromide. Follow label directions. |
| **TOMATO (FIELD)** | |
| Seed decay, damping-off, and seedborne diseases | Plant seed that has been soaked in hot water or household bleach and that has been treated with captan or thiram. See treatment for pepper seed. Use Ridomil Gold EC drench for Pythium damping-off in the seedbed. |
| Bacterial spot, speck, and canker | Purchase only certified, disease-free plants. Use crop rotations of 3 to 4 years, excluding peppers. In the seedbed, spray with fixed copper plus streptomycin. After transplanting, spray with fixed copper plus Bravo, mancozeb, or zoxamide. Actigard has been registered for control of bacterial spot and bacterial speck. Read and follow label directions. Once established, bacterial spot and canker are difficult to control. |
| Septoria blight, early blight, anthracnose, gray leaf spot; leaf mold, gray mold, and white mold (Sclerotinia) | Practice 2- to 3-year crop rotation. Apply Amistar, Bravo, Cabrio, Flint, mancozeb, Quadris, Quadris Opti, Reason, Scala, or zoxamide on a 7- to 10-day schedule after the first sign of disease or after the first fruits form. A soil-surface spray of mancozeb after the last cultivation improves anthracnose control. Ridomil Gold Bravo or Ridomil Gold EC helps control Pythium fruit rots and late blight. Ziram can be used to control anthracnose, early blight, and Septoria leaf spot. Endura can be used to control early blight and gray mold. |
| Late blight | Avoid planting tomatoes near potatoes. Destroy potato tuber cull piles and volunteer potato plants near tomato plantings. Plant disease-free, certified transplants. Practice good field sanitation. Apply Acrobat MZ, Agri-Fos, Amistar, Bravo, Cabrio, Curzate, Flint, Forum (nonstaked tomato), mancozeb, Previcur, ProPhyt, Quadris, Quadris Opti, Ranman, Reason, Ridomil Gold Bravo, Ridomil Gold MZ, Tanos, or zoxamide. |
| Blossom end rot | Choose varieties that are less prone to blossom end rot. Mulch plants or maintain uniform soil moisture. Four weekly applications of calcium nitrate starting when fruits are grape sized may reduce losses. Avoid cultivation close to plants. |
| Buckeye rot | Apply Amistar, Quadris, or Ridomil Gold EC. Follow label directions. |
| Powdery mildew | Apply Amistar, Cabrio, Flint, Nova, or Quadris at 7- to 14-day intervals, beginning with first sign of disease. Do not make more than two sequential applications of Quadris. Read and follow label directions. |

**Table 3. Condensed recommendations on management for diseases of commercial vegetable crops for 2006 (cont.)**

| Vegetable and disease | Disease-management practices |
|---|---|
| **TOMATO (FIELD) (CONT.)** | |
| Verticillium and Fusarium wilts | Grow only resistant (VF) varieties. Avoid soils with a history of wilt. |
| Phytophthora blight | Avoid fields with a history of disease and fields that are poorly drained. Avoid fields in close proximity to pepper or cucurbit fields that have sustained Phytophthora blight in the past. Soil application of Ridomil Gold EC may be effective. Foliar sprays of Ridomil/Bravo during a wet summer may help reduce the incidence of disease. Protectant fungicides, such as Bravo and mancozeb, may offer some degree of control. |
| Viral diseases | Take care to avoid infecting seedlings. Start with virus-free seed. Control insects and broadleaf weeds in and around fields. See upcoming entry on greenhouse tomatoes. |
| Nematodes | Plant root knot–resistant varieties. Vydate L may be applied at planting. Fall fumigation with Vapam also may be used. |
| **TOMATO (GREENHOUSE)** | |
| Viral diseases | Start with hot water–treated seed. Do not allow the use of tobacco on the premises. Smokers should wash their hands with soap and hot water before working with plants. If possible, plant TMV-resistant hybrids. Control insects. Remove the first infected plants if possible. |
| Botrytis gray mold, leaf mold, gray leaf spot, and early blight | Avoid excessive humidity by heating and venting, especially at night during the fall, early winter, and early spring. Spray weekly with Bravo, mancozeb, Quadris, or Ziram. |
| Nematodes, root rots, and soilborne TMV | Steam the plant beds. Plant resistant varieties whenever available. |

## RECOMMENDED WEB RESOURCES

**http://veg-fruit.cropsci.uiuc.edu, http://www.ag.uiuc.edu/~vista/pubs.html, http://ipm.uiuc.edu,** and **http://www.aces.uiuc.edu/~ipm/news/fvnews.html**
For information on vegetable crops in Illinois, *Illinois Fruit & Vegetable News,* current and archived issues. Includes IPM links and "Ask an Expert" section. Published weekly during the summer.

**http://www.APSnet.org**
Information on plant diseases. Web site of the American Phytopathological Society. News features, reports, other public-access information, as well as subscription journals.

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# 10

# Brush Control in Illinois

Brush control is used to improve and maintain pastures, recreational areas, fencerows, drainage-ditch banks, rights-of-way, and other noncrop areas. Table 1 lists the common and scientific names of the brush species referred to in this chapter. Brush can be controlled by mechanical or chemical methods (herbicides) or by a combination of mechanical removal of the plant and herbicides either to control the plant or to minimize resprouting.

## Mechanical Control

Mechanical brush control is time-consuming and costly, but it may be necessary in areas where herbicide use is undesirable. Brush can be controlled by cutting, girdling, or grubbing. *Cutting brush* at ground level can be successful if sprouts are controlled by multiple cuttings or by the use of herbicides. Brush should be cut when food reserves in the roots are lowest (in the spring after full leaf) to minimize production of new sprouts. Any sprouts that develop should be removed until new sprouts no longer develop.

*Girdling* requires cutting a ring of bark and sapwood (the cambium layer) completely around the trunk of a woody plant to inhibit water and nutrient flow between roots and shoots. This practice is most effective in the summer months during sap flow. Girdling is practical only for scattered stands of large trees, as it is labor intensive.

*Grubbing* is the uprooting of plants by pulling or digging. Grubbing is difficult, time-consuming, and costly; but it can be effective if an adequate amount of the root system is removed. Bulldozers are often used to remove brush or trees and are most effective when fitted with special attachments for cutting off the tree below the groundline to lift out the tree and most of the larger roots.

## Chemical Control

Chemical brush control with herbicides is generally less time-consuming and labor intensive than mechanical control. However, chemical control does not remove the dead plants; and foliar "brownout," or dead leaves, may be considered unsightly or offensive in areas of high visibility. An effective chemical brush-control program should be carefully planned and applied to minimize potential environmental and financial risk.

Brush herbicides are registered (labeled) only for certain areas and methods of application. Table 2 lists common brush herbicides and indicates the areas for which they are labeled, the appropriate application methods, and the general types of brush they control. Herbicides applied in pastures or where livestock graze must have grazing and harvest clearances. Some herbicides cannot be applied to aquatic areas, drainage ditches, or areas where they could run off or leach into aquatic areas. Information in this chapter has been taken from herbicide labels, so consult current labels because the information changes over time. Be sure to note and closely follow label restrictions and recommendations, and make applications carefully. Herbicides and their rates for use in brush control are listed in Table 3.

## Methods of Application

Brush herbicides may be applied to the leaves (foliar treatment), onto or into the stem or trunk (basal-bark

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

or cut-surface treatment), or to the soil (Table 2). The best choice depends on many factors, including the herbicide, the site, the season of the year, and the environment. Tables 4 to 7 describe the susceptibility of common brush species to various herbicides applied by foliar, basal-bark, cut-surface, cut-stubble, or soil application. Much of this information was taken from *Response of Selected Woody Plants in the United States to Herbicides* (Agriculture Handbook no. 493, USDA), but it has been modified to match new label and manufacturer information.

**Foliar treatments** are most effective when sprays are applied just after full-leaf expansion, during late spring or early summer; adequate foliar coverage is essential. Foliar herbicide effectiveness is often improved by adding spray adjuvants such as oils (see labels for information). Effectiveness is often reduced if rainfall occurs too soon after application. Adverse temperature and moisture stress also affect foliar penetration and translocation of the herbicide. Foliar applications may be made as low- or high-volume sprays, depending on the equipment, the need for spray coverage, the size of the area, and the sensitivity of the surrounding area to drift. Applications may be broadcast or made as directed sprays with spray guns. Foliar treatments should usually be limited to shrubs or small trees because the drift potential is greater with tall trees.

Drift potential changes with the weather, the choice of herbicide, the herbicide formulation, and the spray equipment. Do not spray when the wind velocity is greater than 5 to 10 miles per hour or when the wind is blowing toward sensitive desirable plants or critical areas. Do not apply low-volume sprays (smaller droplets) during periods of high temperature or low humidity. Low-pressure sprayers have less drift potential than high-pressure sprayers. Specialized nozzles or spray thickeners (drift-reduction agents) may be used to reduce small-droplet formation and spray drift. Certain herbicide formulations volatilize and should not be used when minimizing drift is crucial. Some herbicide labels list sensitive species and critical areas that must be protected from drift or direct application. *Read and follow label precautions about spray or vapor drift to susceptible plants or sensitive areas.*

**Basal-bark treatments** are more labor intensive than foliar treatments, but they are useful as a technique for selectively removing undesirable species from stands of desirable trees. These treatments are used to control brush with trunks or stems less than 5 inches in diameter. Basal-bark treatments may be made throughout the year except when the bark is very wet or covered with ice or when the depth of snow prevents application. However, dormant-season application may be desirable to reduce drift complaints and concerns about foliar brownout.

Oil-soluble, usually ester, formulations of herbicides are applied in diesel oil or kerosene to penetrate the bark. Penetrating oils with less offensive odors are available, but they are more expensive. Standard basal-bark treatments are applied around the lower 12 to 15 inches of the stem, including the root collar and exposed roots. Conventional basal-bark technique uses 1 to 3 percent herbicide in oil, while the low-volume basal-bark technique uses 20 to 30 percent herbicide in oil. Smaller bands (broad band or thin line) using a higher concentration of herbicide in oil can be effective on many species. Follow instructions on the herbicide label.

**Cut-surface treatments** are used to control trees having thick bark or trunks greater than 5 inches in diameter. Application may be made anytime except during heavy sap flow in the spring. Dormant-season application minimizes the potential for drift and foliar brownout complaints. The herbicide is applied into frills or notches cut around the trunk, going through the bark to penetrate at least ½ inch into the sapwood. Treat cuts within 2 or 3 hours of cutting. Special equipment often is used to cut and inject the herbicide into the tree in one operation, reducing labor cost and drudgery. You can minimize sprouting from freshly cut stumps by treating the area next to the bark (cambium) and drenching the root collar (soil at ground level) soon after cutting.

**Cut-stubble treatments** combine cut-surface and soil treatment. Herbicide is broadcast in a water carrier to cut stems and exposed ground soon after a mowing operation. Applications may be made anytime during the year except when the ground is frozen or completely saturated with water. Apply carefully to minimize drift or runoff to off-target species or sensitive areas.

**Soil treatments,** sometimes called basal-soil, are applied within the dripline of the target species so the herbicide can move by rainfall into the root zone. Soil treatments are applied as sprays, granules, or pellets. Because the soil-treatment herbicides are quite persistent and mobile in water, do not use them where they can run off toward or leach into surface- or underground water sources. Do not apply them to frozen ground or land sloping toward nontarget species where lateral movement will be a problem. The killing of nontarget species has been one of the major problems with soil treatments.

## Brush Herbicides

Some brush herbicides are selective, leaving grasses unharmed while controlling brush and broadleaf

weeds. These herbicides can injure desirable broadleaf plants if they are allowed to drift, run off, or leach out of the treatment area. Nonselective herbicides are potentially hazardous to desirable plants, but they may be used as spot treatments to control brush if applied carefully. If possible, dedicate application equipment to a single use or be sure to clean the equipment thoroughly. Most labels have recommendations for type of application equipment and equipment cleaning. Brush herbicides may be growth-hormone regulators, foliar phosphono herbicides, ALS amino acid–synthesis inhibitors, or photosynthetic inhibitors. Each type has specific advantages and disadvantages.

**Growth-hormone regulator herbicides** are absorbed by foliage and plant roots and translocated to growing areas (meristems). These herbicides include 2,4-D, dichlorprop, dicamba, picloram, and triclopyr, plus many mixtures. Prevent drift or runoff into sensitive areas because minute amounts may injure highly sensitive species. Ester formulations are more subject to vapor drift than are amine formulations although dicamba amine can hydrolyze and then volatilize. Vapors can move far from the site of application. Do not apply any of these herbicides when the temperature is expected to exceed 85°F within several days. Ester formulations may be applied in oil carriers for basal-bark treatments, while amine formulations are preferable for injection and cut-surface treatments.

Foliar treatments are often more subject to drift than are other methods of application. Symptoms of injury from growth-hormone herbicides are usually foliar deformities (strapping or cupping) and stem or petiole twisting (epinasty). These herbicides have foliar and soil activity, so do not treat areas where the herbicide may leach or run off and contact the roots of desirable species. Closely follow all restrictions on the labels.

**2,4-D, dichlorprop,** and **dicamba**, as well as their mixtures, are registered for brush control on drainage-ditch banks, rights-of-way, and noncrop areas. Dicamba and 2,4-D also are registered for brush control in pastures, but follow label restrictions on grazing. 2,4-D is sold under many trade names as esters, amines, or salts.

**DPD Ester Brush Killer** is a dichlorprop ester plus 2,4-D ester formulation, while **Brushmaster** is a mix of 2,4-D ester, dichlorprop ester, and dicamba amine. **Banvel, Clarity, Sterling,** or **Vanquish** (dicamba) and **Weedmaster** or **Brash** (dicamba + 2,4-D) may be used for brush control in noncropland or pasture. Clarity and Vanquish are the diglycoylamine formulations of dicamba, with fewer volatility problems than Banvel, which is a dimethylamine.

**Tordon K** (picloram) and **Tordon 101 Mixture, Grazon P + D,** or **Pathway** (picloram + 2,4-D) contain the amine formulation of picloram. Tordon K and Tordon 101 Mixture are restricted use pesticides (RUPs). Pathway, however, is a ready-to-use (RTU), general use herbicide for cut-surface or injection application only.

**Garlon 3A** (triclopyr amine); **Garlon 4, Pathfinder II,** or **Remedy** (all esters); and **Crossbow** (triclopyr ester + 2,4-D ester) all contain triclopyr, which is much less persistent than picloram. All can be used for noncropland brush control. Pathfinder II is an RTU formulation for basal-bark or cut-stump treatment. Crossbow may also be used in grass pastures as a foliar treatment. Check the label for grazing and haying restrictions.

**Foliar phosphono herbicides** such as fosamine and glyphosate are applied to the foliage because they have little soil activity. **Krenite S** (fosamine) may be used where foliar brownout is a problem because treated foliage does not immediately die. It goes through normal fall coloration and leaf drop; but, the next spring, susceptible plants fail to refoliate, and they die. Thorough spray coverage is required for complete control. A spray directed to only part of a susceptible species results in a trimming effect without killing the entire plant.

**Glyphosate** (many formulations) may be used for foliar treatments. There are many different glyphosate formulations; see labels for which ones are used for noncropland, forestry, utility rights-of-way, and general use (including cropland). Some trade names for these products are Roundup Pro, Accord, Glyfos, Touchdown, Credit, and Roundup Weathermax. The glyphosate formulation used for aquatic applications is Rodeo. Glyphosate is nonselective, so it should be applied as a spot treatment for brush where loss of ground cover is detrimental. Some formulations can be used for spot treatment of brush in pastures, but check the product label for grazing restrictions.

**ALS amino acid–synthesis inhibitors** for brush control are imazapyr and metsulfuron. They control both herbaceous and woody broadleaf plants and may suppress or kill some grass species, so read labels carefully before applying near desirable species or sensitive areas. Plants absorb imazapyr and metsulfuron through both foliage and roots and translocate them to growing (meristematic) areas. Growth inhibition of susceptible species occurs rapidly, but typical symptoms of action may not be visible for some time after application. Ultimate effects on brush species may not occur until the season after treatment.

**Arsenal, Chopper,** and **Stalker** contain imazapyr. Arsenal is for general noncropland use, Arsenal AC for forestry use. Chopper and Stalker are registered for noncropland basal-bark and cut-surface brush treatments. Imazapyr controls a broad spectrum of woody and herbaceous (broadleaf and grass) species. Arsenal may be applied pre- or postemergence; but to control perennials, including brush species, postemergence is the method of choice.

Metsulfuron is sold as **Escort** for industrial use and as **Ally** and **Cimarron** for pasture use. Apply as a foliar treatment for control of selected brush species (Table 2). For greatest effectiveness, complete spray coverage of foliage and stems is necessary.

**Photosynthetic inhibitor (PSI) herbicides** used for soil-applied brush control include bromacil, hexazinone, and tebuthiuron. Because these herbicides translocate only in the xylem, they are generally soil applied for brush control; but, when applied to foliage, they provide contact-type activity, especially when a surfactant is added. Injury symptoms on brush are generally slow to appear from soil application because the herbicides require rainfall to infiltrate the soil and to be taken up by the roots. These herbicides are nonselective, so avoid application to the foliage or near the root zone of desirable plant species. Spot treatment is necessary where bare ground is undesirable.

**Hyvar X** (bromacil) may be soil applied for brush control. Hyvar X-L, a liquid formulation, may be soil applied undiluted with a special handheld applicator that delivers a predetermined volume when triggered. Hyvar X-L also is registered for soil-applied spot treatment of brush on ditch banks.

**Velpar** (hexazinone) is available as Velpar L or Velpar DF for spray application to soil in industrial or forestry areas. Velpar is registered for use in alfalfa. Thus, treated areas may be grazed or cut for hay when label restrictions are followed.

**Spike** (tebuthiuron) is available as Spike 80DF for spray application or Spike 20P for direct soil application of pellets. Spike 20P may be used for spot treatment of brush in pastures, but observe grazing and haying restrictions on the label.

*Do not apply PSI herbicides to brush standing in water or spray toward water. Do not apply these herbicides to frozen soil or to areas sloping toward water or desirable species because these herbicides are quite mobile and persistent.*

**Table 1. Common and scientific names of brush species**

| Common names | Scientific names |
|---|---|
| Ash, white | *Fraxinus americana* |
| Birch | *Betula* spp. |
| Box elder | *Acer negundo* |
| Brambles (blackberry, etc.) | *Rubus* spp. |
| Cedar, eastern red | *Juniperus virginiana* |
| Cherry, black and choke | *Prunus serotina, P. virginiana* |
| Cottonwood | *Populus deltoides* |
| Crabapple | *Malus* spp. |
| Elderberry | *Sambucus canadensis* |
| Elm | *Ulmus* spp. |
| Grapes, wild | *Vitis* spp. |
| Greenbriar | *Smilax* spp. |
| Hackberry | *Celtis* spp. |
| Hawthorn | *Crataegus* spp. |
| Honeylocust | *Gleditsia triacanthos* |
| Honeysuckle | *Lonicera* spp. |
| Locust, black | *Robinia pseudoacacia* |
| Maple, red | *Acer rubrum* |
| Maple, silver or sugar | *A. saccharinum, A. saccarum* |
| Mulberry, red and white | *Morus rubra, M. alba* |
| Oak | *Quercus* spp. |
| Olive, Russian | *Elaeagnus augustifolia* |
| Osage orange (hedge) | *Maclura pomifera* |
| Persimmon, common | *Diospyros virginiana* |
| Plum, wild | *Prunus* spp. |
| Poison ivy, poison sumac | *Toxicodendron radicanus, T. vernix* |
| Rose, multiflora | *Rosa multiflora* |
| Sassafras | *Sassafras albidum* |
| Sumac | *Rhus* spp. |
| Tree-of-heaven | *Ailanthus altissima* |
| Trumpetcreeper | *Campsis radicans* |
| Virginia creeper | *Parthenocissus quinquefolia* |
| Willow | *Salix* spp. |

**Table 2. Label clearances for common brush herbicides**

| | Area or site | | | | | | | Application method | | | | | Type of brush | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brush herbicide | CRP areas | Pasture | Fencerows | Forest | Ditch bank | Rights-of-way | Noncrop | Foliar-stem spray | Cut-surface or injection | Conventional basal[a] | Low-volume basal[a] | Soil | Deciduous | Coniferous |
| 2,4-D amine, ester | x | x | x | x | x | x | x | x | x | x[a] | x[a] | — | x | — |
| DPD Brush Killer | — | — | x | x | x | x | x | x | x | x | x | — | x | x |
| Super Brush Killer or Brushmaster | — | — | x | — | x | x | x | x | x | x | — | — | x | x |
| Brash / Weedmaster | x | x | x | — | x | x | x | x | x | — | — | — | x | x |
| Dicamba (many)[b] | x | x | x | x | x | x | x | x | x | x[c] | — | — | x | — |
| Tordon K | — | — | — | x | — | x | x | x | — | — | — | x | x | x |
| Pathway (RTU) | — | — | x | x | — | x | x | — | x | — | — | — | x | x |
| Tordon 101 Mixture | — | — | — | x | — | x | x | x | x | — | — | x | x | x |
| Grazon P + D | x | x | — | — | — | — | x | x | — | — | — | — | x | — |
| Garlon | x | — | x | x | x | x | x | x | x | x[a] | x[a] | — | x | x |
| Remedy | x | x | x | x | x | x | x | x | x | x[a] | x[a] | — | x | x |
| Crossbow | x | x | x | — | x | x | x | x | — | x | x | — | x | x |
| Pathfinder II (RTU) | — | — | — | x | x | x | x | — | — | — | x | — | x | x |
| Krenite S | — | — | — | — | x | x | x | x | — | — | — | — | x | x |
| Glyphosate[d] | x | x[e] | x | x | x | x | x | x | x | — | — | — | x | x |
| Ally, Cimarron | x | x | — | — | — | x | x | x | — | — | — | x | x | x |
| Arsenal | — | — | x | x[f] | x | x | x | x | x | — | — | — | x | — |
| Escort | x | — | x | x | — | x | x | x | — | — | — | x | x | x |
| Stalker / Chopper | x | — | x | x | x | x | x | — | x | x | x | — | x | — |
| Hyvar-X or X-L | — | — | — | — | — | x | x | — | — | — | — | x | x | x |
| Spike | x | x[g] | x | — | — | x | x | — | — | — | — | x | x | x |
| Velpar | — | — | — | x | — | x | x | x | — | — | — | x | x | — |

x = labeled for use; — = not labeled for use.
[a]Oil-soluble ester forms only.
[b]There are many dicamba formulations.
[c]Not for pasture use.
[d]Many trade names (for example, Accord, Roundup Pro, Touchdown, etc.). Be sure to read and follow label directions.
[e]Spot treatment only (10% of each acre).
[f]Use AC formulation.
[g]Soil application only.

**Table 3. Herbicides and rates for brush control**

| Trade name and form | Generic name and form | Rate for foliar spray, ground application[a] | | Rate for basal-bark per 100 gal.[c] |
|---|---|---|---|---|
| | | Per acre | Per 100 gal.[b] | |
| Arsenal 2S | imazapyr | 2–3 qt | 0.5–1 gal. | —[d] |
| Brushmaster | dichlorprop + 2,4-D (esters) + dicamba amine | 1–2 gal. | 1–2 gal. | 4 gal. |
| Crossbow 3E | triclopyr + 2,4-D (esters) | 1.5–4 gal. | 1–1.5 gal. | 1–4 gal. |
| Dicamba (many) | dicamba | 1–2 qt | —[d] | —[d] |
| DPD Brush Killer | dichlorprop + 2,4-D (esters) | 1–2 gal. | 1–1.5 gal. | 3–4 gal. |
| Escort 60DF | metsulfuron | ⅓–1 oz | 1–3 oz | —[d] |
| Garlon 3A | triclopyr, amine | 2–3 gal. | 0.5–1 gal. | —[d] |
| Garlon 4E/Remedy | triclopyr, ester | 0.5–2 gal. | 1–2 gal. | 1–5 gal. |
| Glyphosate (many)[e] | glyphosate | 4–8 pt | 1–2.5 gal. | 1–2 gal. |
| Grazon P + D | picloram + 2,4-D (amines) | 3 qt–1 gal. | 2 gal. | —[d] |
| Hyvar X 80WP | bromacil | 7–15 lb | —[d] | —[d] |
| Hyvar X-L 2S | bromacil | 2.5–6 gal. | —[d] | —[d] |
| Krenite S, UT | fosamine | 1.5–6 gal. | 1.5–3 gal. | —[d] |
| Pathfinder II | triclopyr ester | —[d] | —[d] | RTU[f] |
| Spike 20P | tebuthiuron | 10–30 lb | —[d] | —[d] |
| Stalker 2S | imazapyr | —[d] | —[d] | 0.75–1 gal. |
| Tordon K | picloram | 1–2 qt | —[d] | —[d] |
| Tordon 101 | picloram + 2,4-D (amines) | 1–2 gal. | —[d] | —[d] |
| Velpar 2L | hexazinone | 2–4 gal. | —[d] | —[d] |
| Velpar 75DF | hexazinone | 5–10 lb | —[d] | —[d] |
| Weedmaster 3.87S | dicamba + 2,4-D (amines) | 2.0 gal. | —[d] | —[d] |
| Weedone LV4 | 2,4-D ester | 1–2 gal. | 2 gal. | —[d] |

[a]See label for aerial application.
[b]Foliar mix: herbicide + water (+ 1 gal. oil + emulsifier if label allows).
[c]Basal-bark spray mix: herbicide + fuel oil total.
[d]Not labeled for this purpose.
[e]Rates based on 3 lb a.e. per gallon formulations.
[f]RTU = Ready-to-use formulation; apply undiluted.

**Table 4. Foliar herbicide treatment: Susceptibility of common brush species**

| | 2,4-D | Arsenal | Brushmaster | Crossbow | dicamba[a] | DPD Brush Killer | Escort | Garlon/ Remedy | glyphosate[b] | Hyvar | Krenite S | Tordon 101/ Grazon P + D | Weedmaster |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ash, white | P | G | F | F | F | P | G | F | F | F | F | P | P |
| Birch | F | P | G | F | G | F | P | F | F | F | G | F | F |
| Box elder | F | F | G | F | — | F | P | P | FG | G | FP | G | F |
| Brambles (blackberry, etc.) | P | P | F | G | F | F | G | G | F | F | FG | F | F |
| Cedar, eastern red | P | P | P | P | FP | P | F | P | P | F | P | F | P |
| Cherry, black and choke | FP | G | F | FG | G | F | G | FG | G | G | F | FG | G |
| Cottonwood, eastern | FG | G | G | FG | G | F | F | G | F | G | FG | G | G |
| Crabapple | F | — | G | FG | G | G | — | FG | G | — | — | G | G |
| Elderberry | FG | G | G | FG | G | F | P | G | G | G | FG | G | G |
| Elm, American and slippery | F | P | F | F | F | F | G | F | F | F | F | F | F |
| Grapes, wild | FG | G | FG | G | F | FG | F | G | G | — | G | FG | F |
| Greenbriar | P | G | F | P | FP | P | P | FP | P | P | P | FP | F |
| Hackberry | FP | P | F | G | F | F | P | G | F | F | FP | FG | F |
| Hawthorn | FP | G | F | F | FP | P | G | F | FG | F | F | FG | F |
| Honeylocust | P | G | F | FG | FP | F | P | FG | P | F | F | G | P |
| Honeysuckle | F | G | F | FP | F | G | F | FP | F | F | F | G | F |
| Locust, black | F | P | G | G | G | FG | F | G | F | P | G | F | G |
| Maple, red | P | G | P | F | FP | P | F | FG | F | F | F | F | P |
| Maple, silver or sugar | P | G | F | G | F | — | G | G | F | F | F | F | F |
| Mulberry, red or white | P | G | F | F | F | P | P | F | P | F | F | F | P |
| Oak | P | G | F | F | F | F | FG | FG | FG | F | G | P | F |
| Olive, Russian | F | G | — | F | F | — | P | FG | F | — | F | G | F |
| Osage orange (hedge) | P | P | P | F | FP | P | F | F | P | F | F | F | P |
| Persimmon, eastern | F | F | F | F | FG | P | P | F | F | P | F | FG | FP |
| Plum, wild | FG | G | FG | F | FG | F | P | FG | G | — | FG | G | F |
| Poison ivy | F | G | F | G | FG | F | P | G | F | F | P | F | F |
| Rose, multiflora | F | G | G | G | G | G | F | FG | G | F | F | G | G |
| Sassafras | F | G | F | F | F | F | P | F | F | F | F | G | F |
| Sumac | F | G | G | G | FG | G | P | G | F | F | G | FG | G |
| Tree-of-heaven | F | F | F | FG | P | F | P | G | F | F | FG | FG | P |
| Trumpetcreeper | P | FP | FP | P | FG | P | P | P | F | P | F | P | F |
| Virginia creeper | FG | G | G | F | FP | F | G | F | F | G | P | F | F |
| Willow | G | G | G | G | FG | G | G | FG | F | F | F | G | G |

G = good; F = fair; P = poor; FG = fair to good; FP = fair to poor; — = no information available. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agricultural Handbook no. 493, U.S. Department of Agriculture, and from herbicide companies.

[a]There are many dicamba formulations.

[b]There are many glyphosate formulations.

**Table 5. Conventional basal-bark herbicide treatment: Susceptibility of common brush species**

| | 2,4-D ester | Brushmaster | dicamba[a] | Garlon 4/ Remedy | Stalker | Weedone CB/ Weedone 170 |
|---|---|---|---|---|---|---|
| Ash, white | P | FG | FG | G | G | P |
| Birch | G | F | G | G | G | F |
| Box elder | G | G | G | P | G | G |
| Brambles (blackberry, etc.) | FG | G | G | G | F | F |
| Cedar, eastern red | P | F | FG | F | P | P |
| Cherry, black and choke | F | F | G | G | G | F |
| Cottonwood, eastern | G | G | G | G | G | F |
| Crabapple | FG | G | G | — | — | FG |
| Elderberry | FG | G | G | G | G | FG |
| Elm, American and slippery | FG | FG | G | F | FG | F |
| Grapes, wild | — | F | F | FG | G | F |
| Greenbriar | F | F | P | P | G | P |
| Hackberry | G | F | FG | G | P | G |
| Hawthorn | F | F | FP | F | — | F |
| Honeylocust | F | F | F | G | FG | FP |
| Honeysuckle | G | G | G | P | G | F |
| Locust, black | F | F | FG | FG | P | F |
| Maple, red | P | P | G | FG | G | P |
| Maple, silver or sugar | FP | F | G | G | G | FP |
| Mulberry, red or white | P | FP | F | F | G | P |
| Oak | P | G | G | G | G | FG |
| Olive, Russian | — | — | F | FG | G | — |
| Osage orange (hedge) | F | F | P | P | P | F |
| Persimmon, eastern | FP | F | G | F | G | P |
| Plum, wild | FG | FG | G | P | G | FG |
| Poison ivy | F | F | FG | P | G | F |
| Rose, multiflora | F | FG | F | F | G | F |
| Sassafras | FG | FP | FG | FG | G | F |
| Sumac | F | F | G | G | G | G |
| Tree-of-heaven | FP | F | F | G | FG | F |
| Trumpetcreeper | P | G | FG | P | G | P |
| Virginia creeper | P | G | — | P | G | P |
| Willow | G | G | — | FG | G | F |

G = good; F = fair; P = poor; FG = fair to good; FP = fair to poor; — = no information available. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agricultural Handbook no. 493, U.S. Department of Agriculture, and from herbicide companies.

[a]There are many dicamba formulations.

**Table 6. Injection, cut-surface, and cut-stubble herbicide treatment: Susceptibility of common brush species**

| | 2,4-D amine | Arsenal/ Stalker | Brushmaster | dicamba[a] | DPD Brush Killer | Garlon 3A | Pathway |
|---|---|---|---|---|---|---|---|
| Ash, white | P | G | FG | G | F | F | FG |
| Birch | F | G | FG | G | FG | F | FG |
| Box elder | F | G | F | — | F | G | G |
| Cedar, eastern red | P | P | F | FG | F | FP | F |
| Cherry, black and choke | G | G | FG | — | FG | FG | G |
| Cottonwood, eastern | G | G | G | — | F | G | G |
| Crabapple | — | — | G | — | — | G | G |
| Elderberry | F | G | G | — | F | FG | G |
| Elm, American and slippery | G | F | FG | — | F | F | F |
| Grapes, wild | FG | F | FP | — | P | FG | FG |
| Greenbriar | P | P | F | — | F | P | P |
| Hackberry | F | P | F | — | F | G | G |
| Hawthorn | F | F | F | — | F | F | F |
| Honeylocust | F | F | G | — | G | F | G |
| Honeysuckle | P | G | F | — | F | P | G |
| Locust, black | G | F | G | — | FG | G | G |
| Maple, red | P | G | F | F | F | G | F |
| Maple, silver or sugar | P | G | F | FG | F | G | G |
| Mulberry, red or white | F | G | F | — | F | F | F |
| Oak | P | G | G | P | G | G | F |
| Olive, Russian | — | G | — | F | — | G | G |
| Osage orange (hedge) | F | P | F | — | F | F | F |
| Persimmon, eastern | F | G | F | G | F | F | F |
| Plum, wild | F | G | F | — | F | FG | F |
| Poison ivy | F | G | FG | — | FG | G | F |
| Rose, multiflora | FP | G | G | — | G | F | F |
| Sassafras | G | G | F | — | F | F | F |
| Sumac | F | G | G | — | G | G | F |
| Tree-of-heaven | F | FG | F | — | F | G | G |
| Trumpetcreeper | F | G | F | — | — | P | P |
| Virginia creeper | P | G | F | — | — | F | F |
| Willow | G | G | F | — | FG | FG | G |

G = good; F = fair; P = poor; FG = fair to good; FP = fair to poor; — = no information available. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agricultural Handbook no. 493, U.S. Department of Agriculture, and from herbicide companies.

[a]There are many dicamba formulations.

**Table 7. Soil herbicide treatment: Susceptibility of common brush species**

| | Hyvar X-L | Spike 20P | Velpar |
|---|---|---|---|
| Ash, white | F | F | F |
| Birch | FG | FG | F |
| Box elder | G | G | FG |
| Brambles (blackberry, etc.) | F | F | F |
| Cedar, eastern red | F | FP | F |
| Cherry, black and choke | FG | FG | FG |
| Cottonwood, eastern | FG | G | G |
| Crabapple | F | — | F |
| Elderberry | G | G | G |
| Elm, American and slippery | F | FG | F |
| Grapes, wild | G | G | FG |
| Greenbriar | P | F | P |
| Hackberry | FG | G | G |
| Hawthorn | P | F | G |
| Honeylocust | F | FG | G |
| Honeysuckle | F | G | G |
| Locust, black | G | F | G |
| Maple, red | F | F | F |
| Maple, silver or sugar | F | FG | G |
| Mulberry, red or white | F | G | FG |
| Oak | F | G | FG |
| Olive, Russian | — | FG | FG |
| Osage orange (hedge) | F | P | FG |
| Persimmon, eastern | F | P | F |
| Plum, wild | G | G | FG |
| Poison ivy, poison sumac | G | FP | FG |
| Rose, multiflora | F | G | G |
| Sassafras | F | P | FP |
| Sumac | G | G | F |
| Tree-of-heaven | FG | G | F |
| Trumpetcreeper | P | F | P |
| Virginia creeper | P | FG | F |
| Willow | FG | F | FG |

G = good; F = fair; P = poor; FG = fair to good; FP = fair to poor; — = no information available. Data are adapted from *Response of Selected Woody Plants in the United States to Herbicides*, Agricultural Handbook no. 493, U.S. Department of Agriculture, and from herbicide companies.

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# Weed Control for Noncrop Areas

Total vegetation management is the application of nonselective chemicals or nonselective rates of selective chemicals as a means of controlling all vegetation in noncrop areas such as parking lots, drive-in theater lots, driveways, and certain industrial sites.

Herbicides may be classified by their length of control. Those with little or no residual activity are the contact herbicides, such as paraquat, which control only the existing vegetation that the spray contacts.

Dicamba gives residual control for 4 months or less. Products that provide longer control include bromacil, diuron, tebuthiuron, sulfometuron, prometon, and picloram.

Total vegetation management is desirable along fences, beneath asphalt pavement, along railroads, and around buildings as a means of preventing the growth of weeds that are unsightly or weeds that present a fire hazard. As an alternative to chemical control in some noncrop areas, it may be preferable to establish desirable, competitive vegetation to discourage weed growth and to provide protective soil and wildlife cover. Herbicides with little or no residual activity may be used for temporary control until desirable vegetation is established.

## Precautions and General Procedures

Several precautions must be observed when nonselective chemicals are used. Know what weeds are to be controlled, and select the correct chemical for those particular problems. Survey the area, noting any desirable vegetation in the immediate area or adjacent areas that could be affected by spray drift, chemical runoff, or herbicide leaching into the root zone.

Appropriate precautions should be taken to prevent damage to desirable plants. The risk of injury with certain materials may be too great to allow their use in some areas. Be certain that you are familiar with the product, and be aware of the risks before using any herbicide. Some treatments should be made only by professional applicators.

The type of vegetation to be controlled will affect your choice of a chemical. For example, perennial grasses can be controlled with glyphosate; woody perennials can be controlled with 2,4-D, fosamine, picloram, triclopyr, or mixtures of some of these products. Deep-rooted vines, such as bindweed, can be controlled with dicamba, picloram, triclopyr, or premixes of these herbicides.

## Herbicides for Noncrop Areas

### Herbicides for Long-Term (Soil-Residual) Control

Trees and woody ornamentals are sensitive to these herbicides. Lateral movement or direct application over the rooting zone of desirable woody species can lead to liability and/or litigation. Spray applications (Table 1) used on large areas often involve water-dispersible (DF, DG, or L) formulations that require thorough spray agitation. Granular (G) or pellet (P) formulations (Table 2) are convenient for spot or small-area applications.

The best time to apply nonselective, soil-residual herbicides is early in the spring before herbaceous weeds have emerged. If vegetation is dense, it may be necessary to cut or mow existing vegetation. For a later application, add a contact or translocated foliar herbicide, or mix the herbicide with diesel fuel to speed

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*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

**Table 1. Spray applications for long-term weed control**

| Herbicide | Formulations | Rate of formulation per acre | | |
|---|---|---|---|---|
| | | Annuals | Some perennials | "Hard to control" perennials |
| Arsenal | 2AS | 2 to 4 pt | 1 to 6 pt | 4 to 6 pt |
| Hyvar X | 80WP | 3 to 6 lb | 7 to 15 lb | 7 to 15 lb |
| Hyvar X-L | 2L | 0.75 to 3 gal. | 3 to 6 gal. | 3 to 6 gal. |
| Karmex, Direx | 80DF | 5 to 15 lb | 5 to 15 lb | 5 to 15 lb |
| Krovar | 80DF | 4 to 6 lb | 7 to 18 lb | 19 to 30 lb |
| Oust XP | 75DG* | 3 to 5 oz | 6 to 8 oz | 6 to 8 oz |
| Pramitol 25E | 2S | 4 to 6 gal. | 7.5 to 10 gal. | 10 gal. |
| Spike | 80DF | 5 to 7.5 lb | 2.5 to 5 lb | 3.75 to 7.5 lb |
| Velpar | 75DF | 2.5 to 6.5 lb | 6 to 10.67 lb | — |
| Velpar L | 2L | 1 to 2.5 gal. | 3 to 4 gal. | — |

— = not labeled for this formulation.
*Note that the rate of this product is in ounces per acre.

**Table 2. Application rates for selected granular herbicides**

| Herbicide | Lb per 1,000 sq ft |
|---|---|
| Pramitol 5PS | 3.5 to 9.2 |
| Spike 20P | 0.23 to 0.7 |
| Topsite 2.5G | 5 to 7 |

topkill. Follow label recommendations. After existing vegetation is under control, the rate of a soil-applied herbicide may be reduced for maintenance applications. Adjust application rates according to the soil type, the plant species to be controlled, and desired length of control.

Imazapyr and sulfometuron are acetolactate-synthase (ALS) inhibitors, while bromacil, diuron, hexazinone, prometon, and tebuthiuron are photosynthetic inhibitors (PSI). *Certain biotypes of weed species such as kochia are resistant to PSI and ALS herbicides.*

**Arsenal 2AS** (imazapyr) may be foliar- or soil-applied. **Topsite 2.5G** (imazapyr + diuron) is a granular formulation. **Oust XP 75DG** (sulfometuron) is primar-ily soil-applied.

**Hyvar X 80WP** and **Hyvar X-L 2L** (bromacil) are for spray application. *Hyvar X-L is combustible.* Bromacil also is formulated as a 4 percent granule under many trade names. **Karmex 80DF** (diuron) and **Krovar 80DF** (1:1 bromacil + diuron) are soil-applied, while **Velpar 2L** or **75DF** (hexazinone) may be foliar- or soil-applied. Do not use Hyvar, Krovar, or Velpar around wells or if surface water is present. The Velpar label carries the signal word "Danger," requiring eye protection and rubber gloves for handling.

**Pramitol 25E** (prometon) may be foliar- or soil-applied, while **Pramitol 5PS** is formulated for soil application only. **Spike 80DF** or **20P** (tebuthiuron) is soil-applied for broadleaf weed and brush control. Spike 20P may be used for brush control in pastures.

### Herbicides for Short-Term (Nonresidual) Control

**Gramoxone Max**[RUP] **3S** (paraquat) is a contact herbicide. Use a crop-oil concentrate or nonionic surfactant, and adjust water volume to provide maximum coverage of vegetation. **Finale** (glufosinate) is another contact herbicide that can be used in noncrop areas. Maximum spray coverage is imperative for adequate control. Because **glyphosate** formulations are translocated (systemic) herbicides, they control perennial weeds better than Gramoxone Max and Finale.

## Herbicides for Broadleaf Weed and Brush Control

### Plant-Growth Regulators (PGR)—Primarily Foliar

**2,4-D** is sold under many trade names as acid, amine, salt, or ester formulations. Amines are nonvolatile, while ester formulations are subject to volatile drift under high temperatures. Because 2,4-D formulations

vary in acid equivalent (a.e.) per gallon or pound, rates per acre vary with trade names and formulations. 2,4-D is often mixed with other active ingredients to broaden the spectrum and reduce the cost of control.

**Banvel 4S, Clarity 4L, Sterling 4S,** or **Vanquish 4S** (dicamba); **Distinct 70WG** (dicamba + diflufenzopyr); **Brash** or **Weedmaster** (1:3 dicamba + 2,4-D); **Garlon 4E, Garlon 3A,** or **Remedy** (triclopyr); and **Crossbow** (2:1 triclopyr + 2,4-D) are used in noncrop land. Banvel, Clarity, Brash, Crossbow, Sterling, and Weedmaster also may be used in pastures.

**Tordon K[RUP] 2S** (picloram) and **Tordon 101 Mixture[RUP]** (picloram + 2,4-D) are formulated as amines for foliar application. **Pathway** (picloram + 2,4-D) is for cut-surface applications for brush control in noncrop land. *Do not use picloram in pastures in Illinois.*

**DPD Ester Brush Killer** (1:1 diclorprop + 2,4-D) or **Brushmaster 2E** (diclorprop + 2,4-D + dicamba) is for use in noncrop land. *Diclorprop is not registered for use in pastures.* **Stinger** or **Transline** (clopyralid) is used primarily for Canada thistle control.

#### Other Modes of Action

**Arsenal 2AS** (imazapyr) is used for foliar or soil application, while **Stalker 2S** (imazapyr) is for basal-bark or cut-surface application to control brush. **Escort 60DF** (metsulfuron) and **Telar 75DF** (chlorsulfuron) are for foliar or soil application. Arsenal, Stalker, Escort, and Telar are acetolactate-synthase (ALS) inhibitors. *Resistant biotypes of weed species such as kochia may not be controlled.*

**Bromoxynil** (many trade names: Buctril, Connect, Moxy, Bromox, Broclean, etc.) has contact activity against broadleaf weeds but only suppresses perennials. *Because bromoxynil is toxic to fish, observe proper precautions around water.*

**Krenite S 4S** (fosamine) is used for total control or side trimming of brush, depending upon the portion of the plant sprayed. When Krenite S 4S is applied within 2 months of autumn color, there is no foliar "brownout." Susceptible plants fail to refoliate the following spring.

### Control of Broadleaf Weeds

Broadleaf weeds often are controlled best with foliar applications. Deep-rooted perennials can usually be controlled best when they are at the early bud or bloom stage. Some of the herbicides listed in Table 3 can move through the air and damage nearby desirable trees, shrubs, and broadleaf plants. Some of the herbicides are mobile in the soil and can damage desirable broadleaves if applied to the soil near their roots. See Table 3 for guidelines on appropriate rates.

### Control of Undesirable Woody Plants

Most of the herbicides used to control woody plants are applied to the foliage, but many also may be applied as basal-bark treatments if the woody plants have stems smaller than 5 inches in diameter or as cut-surface (frilled) treatments if the plants are larger. Basal-bark treatments usually are applied in fuel oil. Application may be made throughout the year, even during the dormant season. Cut-surface treatments also may be made throughout the year, but the herbicides should be applied to the cut surface within 2 to 3 hours of cutting. Foliar treatments usually are applied in the spring as soon as the leaves of brush or trees have fully expanded. See Chapter 10, "Brush Control in Illinois," for more detailed information on method of application. See Table 4 for guidelines on appropriate rates and methods of application.

### Weedy Grass Control

Weedy grasses can be controlled with the herbicides listed in Table 5. The use of a surfactant is labeled for some of these herbicides. Before using, read the product label carefully; some of the products listed are nonselective and kill broadleaves as well as grasses.

### Contact Weed Control

**Gramoxone Max** (paraquat), **Finale** (glufosinate), and **bromoxynil** (many names) are contact herbicides requiring an adequate spray volume for complete foliar coverage. Gramoxone Max and Finale control annual grass and broadleaf weeds, while bromoxynil controls only broadleaf weeds. A surfactant or crop-oil concentrate is required with Gramoxone Max and may increase control with bromoxynil under cool, dry conditions. *Do not apply bromoxynil with backpack or handheld equipment.*

### Comments

Whenever possible, use desirable plants to compete with and replace undesirable plants. For some areas, mechanical control may be the most practical and appropriate method.

Availability, formulations, trade names, and federal clearance for the use of herbicides change occasionally. Always refer to the most recent product label for precautions, directions, and application rates. Use herbicides appropriately to avoid injury to yourself and others, desirable nontarget vegetation, and the environment.

**Table 3. Herbicides for broadleaf weed control**

| Herbicide | Rate of formulation per acre | |
|---|---|---|
| | Annuals and "easy to control" perennials | "Hard to control" perennials |
| 2,4-D | 1 to 2 qt | 2 to 4 qt |
| Bromoxynil (many) | 1 to 2 pt[a] | 1 to 2 pt[a] |
| Brushmaster (2,4-D + 2,4-DP + dicamba) | 2 to 4 qt | 4 to 8 qt |
| Crossbow (triclopyr + 2,4-D) | 1 to 2 qt | 2 to 4 qt |
| Dicamba (many) | 0.5 to 1 qt | 1 to 2 qt |
| Distinct (dicamba + diflufenzopyr)[b] | 4 to 6 oz | 4 to 6 oz |
| Escort (metsulfuron)[b] | 0.5 to 1 oz | 1 to 3 oz |
| Finale 1S (glufosinate) | 2 to 4 qt | 4 to 6 qt |
| Garlon 3A (triclopyr) | 2 to 3 qt | 3 to 12 qt |
| Garlon 4/Remedy (triclopyr) | 1 to 2 qt | 2 to 8 qt |
| Glyphosate (many) | 0.5 to 3 qt | 3 to 5 qt |
| Gramoxone Max (paraquat) | 1.5 to 3 pt | 1.5 to 3 pt[a] |
| Oust (sulfometuron)[b] | 3 to 5 oz | 6 to 8 oz |
| Stinger, Transline (clopyralid) | 0.33 to 0.5 pt | 0.67 to 1.33 pt |
| Telar DF (chlorsulfuron)[b] | 0.25 to 1 oz | 1 to 3 oz |
| Tordon 101 Mixture (picloram + 2,4-D) | 2 to 3 qt | 1 to 2 gal. |
| Tordon K (picloram) | 0.5 to 2 qt | 2 qt |
| Weedmaster, Brash (2,4-D + dicamba) | 0.5 to 4 pt | 4 to 6 pt |

[a]Only suppresses perennials.
[b]Note that the rate of this product is given in ounces per acre.

**Table 4. Herbicides for woody plant control**

| Herbicide | Method of application | Rate of formulation |
|---|---|---|
| 2,4-D ester | Foliar or basal-bark | 2 to 4 qt/A |
| Arsenal 2AS (imazapyr) | Foliar or cut-surface | 2 to 3 qt/A |
| Brushmaster (2,4-D + 2,4-DP + dicamba) | Foliar | 1 to 2 gal./100 gal. water |
| Crossbow (triclopyr + 2,4-D) | Foliar | 4 to 6 qt/A |
| | Basal-bark | 1 to 4 gal./100 gal. fuel oil |
| Dicamba (many) | Foliar | 1 to 2 qt/A |
| Distinct (dicamba + diflufenzopyr) | Foliar | 4 to 6 oz/A |
| Garlon 3A (triclopyr) | Foliar or cut-surface | 2 to 3 gal./A |
| Garlon 4/Remedy (triclopyr) | Foliar or basal-bark | 4 to 8 qt/A |
| Glyphosate (many trade names)[a] | Foliar or cut-surface | 2 to 5 qt/A |
| | Spot treatment | 1 to 2% solution |
| Krenite S (4 lb/gal.) | Basal-bark | 1 to 5 gal./100 gal. water |
| | Foliar | 1.5 to 6 gal./A |
| Pathway (picloram + 2,4-D) | Cut-surface | Wet cambium thoroughly. |
| Patron 170 (2,4-D + diclorprop) | Basal-bark or cut-surface | 3 to 4 gal./100 gal. spray |
| Stalker (2 lb/gal. imazapyr) | Basal-bark or cut-surface | 8 to 16 oz/gal.; wet cambium thoroughly. |
| Tordon K (picloram) | Foliar | 1 to 4 qt/100 gal. spray |
| Tordon 101 Mixture (picloram + 2,4-D) | Foliar or cut-surface | 1 to 2 gal./A |
| | Foliar or soil | 1 to 2 qt/A |

[a]Glyphosate rates based on 3 lb a.e./gal. formulation.

**Table 5. Herbicides for weedy grass control**

| | Rate of formulation per acre | |
|---|---|---|
| Herbicide | Annuals | Perennials |
| Assure II (quizalofop) | 5 to 10 fl oz | 12 to 16 fl oz |
| Glyphosate (many)[a] | 0.38 to 2 qt | 1 to 5 qt |
| Select (clethodim) | 6 to 10 fl oz | 8 to 16 fl oz |
| Vantage (sethoxydim) | 2.25 to 2.5 pt | 3.0 to 3.75 pt |

[a]Glyphosate rates based on 3 lb a.e./gal. formulation.

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# 12

# Application Equipment and Calibration References

## Nozzle Nomenclature

Many types of spray nozzles are available, each providing different flow rates, spray angles, droplet sizes, and spray patterns. Some commonly used nozzle types are shown in Figures 1 and 2. Nozzles that produce flat-fan spray patterns are in Figure 1, and those that produce cone spray patterns are in Figure 2.

Table 1 may be used as a guideline for selecting the proper nozzle type for each application. Nozzle manufacturers often code spray nozzles to indicate specific spray characteristics. The tip number may indicate the nozzle type, flow rate, and spray-fan angle. Other characteristics are identified, with letters representing specific operating conditions. Many nozzles are now color-coded for ease of identification, and Table 2 gives the color codes used by the International Organization for Standardization (ISO).

## Sprayer Calibration Guidelines

### Variables Affecting Application Rate

Three variables affect the amount of spray mixture applied per acre: the nozzle flow rate, the ground speed of the sprayer, and the effective sprayed width per nozzle.

The gallons of spray applied per acre may be determined from the three variables in the following equation:

$$\text{GPA} = \frac{\text{GPM} \times 5{,}940}{\text{MPH} \times \text{W}}$$

where

GPA = spray applied, in gallons per acre

GPM = output per nozzle, in gallons per minute

MPH = ground speed, in miles per hour

W = effective sprayed width per nozzle, in inches.

For broadcast spraying, W = the nozzle spacing. For band spraying, W = the bandwidth. For row-crop applications (such as spraying from drop pipes or directed spraying), W = row spacing (or bandwidth) divided by the number of nozzles per row (or band).

5,940 = a constant to convert gallons per minute, miles per hour, and inches to gallons per acre

### Selecting the Proper Nozzle Tip

The proper nozzle size may be selected by determining the required flow rate from each nozzle at a selected application rate (GPA), ground speed (MPH), and effective sprayed width (W) in inches per nozzle. The required flow rate per nozzle may be determined from the following equation:

$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times \text{W}}{5{,}940}$$

Select a nozzle that gives the required flow rate and droplet sizes when the nozzle is operated within the recommended pressure range.

The range of droplet sizes emitted from a nozzle is called the droplet spectrum. Droplet spectra are grouped into six categories. The American Society

of Agricultural Engineers (ASAE) S572 standard, or set of rules, describes the categories as *very fine, fine, medium, coarse, very coarse,* or *extremely coarse.* These terms are listed in Table 3, along with the standard colors that are used to represent them in catalog charts. To apply pesticides using the optimum droplet size, choose nozzles based on the desired droplet spectrum category. This will help balance drift reduction with target coverage. Table 4 gives recommended droplet size spectrums for the applications listed in Table 1.

### Calibrating the Sprayer

Install the selected nozzle tips in the sprayer. Determine the flow rate for each nozzle in ounces per minute (OPM) from the following equation:

**OPM = GPM x 128 (1 gallon = 128 ounces)**

Measure the flow rate using a flow meter, or collect the output from a nozzle using a container marked in ounces. Adjust the pressure until the required GPM or OPM is collected. Check the nozzle flow rate frequently. Adjust the pressure to compensate for small changes in output resulting from nozzle wear. Replace the nozzle tips and recalibrate when the output has changed 10 percent or more from that of a new nozzle or when the pattern has become uneven.

## Flow Rate

Nozzle flow rate varies with spraying pressure. The relationship between GPM and pressure (pounds per square inch, or PSI) is as follows:

$$\frac{GPM_1}{GPM_2} = \frac{\sqrt{PSI_1}}{\sqrt{PSI_2}}$$

With this relationship, doubling the flow through the nozzle requires increasing the pressure by a factor of four. The equation may be used to determine nozzle flow rates achieved at various pressures.

**Example:**

If a certain nozzle has a flow rate of 0.6 GPM at a pressure of 40 PSI, what would the flow rate be if the nozzle were operated at 15 PSI?

**Solution:**

Rearrange the formula to obtain $GPM_2$:

$$GPM_2 = \frac{\sqrt{PSI_2}}{\sqrt{PSI_1}} \times GPM_1$$

Solve for the new flow rate:

$$GPM_2 = \frac{\sqrt{15\ PSI}}{\sqrt{40\ PSI}} \times 0.6\ GPM$$

$$GPM_2 = \frac{3.873}{6.325} \times 0.6$$

$$GPM_2 = 0.61 \times 0.6 = 0.4$$

## Effect of Solution Density on Nozzle Flow Rate

Density is the weight of a solution per unit volume (pounds per gallon). Specific gravity (SG) is the weight of a solution relative to water, which weighs 8.34 pounds per gallon. Nozzle flow rate varies inversely with the square root of specific gravity. Conversion factors to compare flow rates of solutions of any known density may be calculated as follows:

$$\text{Conversion factor} = \sqrt{SG}$$

Table 5 may be used to predict the flow rate for various solutions and to select the proper nozzle size from a nozzle catalog table. Because nozzle tables are based on spraying water, the conversion factors from the table may be multiplied by the desired GPM or GPA to determine the water flow rate for the solution being sprayed. Use the converted GPM or GPA to select the proper nozzle size from the catalog.

**Example:**

**3 GPM (28% N) x 1.13 = 3.39 (water)**

If the flow rate (GPM) or application rate (GPA) of water is known, the GPM or GPA of a solution may be predicted by dividing the flow or application rate by the conversion factor.

**Example:**

**20 GPA (water) ÷ 1.13 = 17.7 GPA (28% N)**

## Measuring Ground Speed

To measure ground speed, mark off a distance in the field to be sprayed or in a field with similar surface conditions. Suggested distances are 100 feet for speeds up to 5 miles per hour, 200 feet for speeds from 6 to 10 miles per hour, and at least 300 feet for speeds above 10 miles per hour. At the engine throttle setting and gear used for actual spraying, determine the travel time between the measured stakes. Calculate ground speed using Table 6, or apply the following formula:

$$\text{Travel speed (MPH)} = \frac{\text{distance (feet)} \times 60}{\text{time (seconds)} \times 88}$$

## Spray Overlap

For uniform application, each nozzle type must be operated at a spacing and height that provide a specific spray overlap. The overlap may vary from 20 percent to more than 100 percent. The percent overlap or spray coverage is illustrated in Figure 3 and Table 7 and may be calculated from the following formulas:

$$\text{Percent overlap} = \frac{\text{spray coverage} - \text{nozzle spacing}}{\text{nozzle spacing}}$$

$$\text{Spray coverage} = (\text{nozzle spacing} \times \text{percent overlap}) + \text{nozzle spacing}$$

## Spray-Angle Coverage at Various Heights

Table 8 lists the theoretical coverage of spray patterns, as calculated from the included angle of the spray and the distance from the nozzle orifice (Figure 4). These values are based on the assumption that the spray angle remains the same throughout the entire spray distance. In practice, the tabulated spray angle does not hold for long spray distances. Adjust the spray height to give proper spray overlap. Table 9 lists suggested minimal spray heights.

## Nozzle Wear

Nozzle tips are available in a variety of materials, including hardened stainless steel, stainless steel, thermoplastic, and brass. Ceramic and hardened stainless steel are the most wear-resistant materials but also are the most expensive. Stainless steel tips have excellent wear resistance when used with either corrosive or abrasive products. Nylon and other synthetic plastics (thermoplastics) are resistant to corrosion and abrasion, but they vary considerably in their wear life, depending on the material used to mold the tips. Brass tips wear rapidly when used to apply abrasive products such as wettable powders, and they are corroded by some liquid fertilizers.

Figure 5 shows the percent increase in flow rates after a 40-hour wear test for flat-fan nozzles constructed of various materials.

## Techniques for Reducing Spray Drift

When pesticides are applied, there is always a chance that some will escape from the target area. Although drift cannot be eliminated completely, the use of proper equipment and spraying techniques maintains drift deposits within acceptable limits. The type of nozzle, pressure, height, and spray volume all affect the off-target movement. The ability to reduce drift is no better than the weakest component in the spraying procedure. A summary of recommended procedures for minimizing spray drift is given in Table 10.

One of the best practices available for minimizing drift damage is the use of drift-control additives to increase the size of spray droplets. Tests indicate that downwind drift deposits are reduced from 50 to 80 percent with the use of drift-control additives. They do not eliminate drift, however, and common sense must remain the primary factor in reducing drift damage. A number of additives are commercially available; they must be mixed and applied according to label directions to be effective.

## Pressure Drop Through Spraying Systems

Hoses and fittings must be selected to keep pressure drops within acceptable limits. Tables 11 to 13 give pressure drops through various sizes of hose, pipe, and coupling. The information in Table 14 is provided for reference in making any conversions needed to calibrate spray equipment properly during pesticide application.

**Table 1. Recommended nozzle types for various applications made with a boom sprayer**

| Type of application | Extended-range flat-fan | Twin flat-fan | Pre-orifice and drift-reduction flat-fan | Turbo flat-fan | Air-induction flat-fan | Flood, turbo-flood, and high-flow | Hollow-cone |
|---|---|---|---|---|---|---|---|
| Contact insecticide and fungicide | R | HR | R | R | R | — | — |
| Systemic insecticide and fungicide | R | R | R | HR | HR | — | — |
| Postemergence contact herbicide | R | HR | R | R | R | — | — |
| Postemergence systemic herbicide | R | — | R | HR | HR | R | — |
| Preemergence herbicide | — | — | R | R | R | HR | — |
| Incorporated soil-applied pesticide | — | — | R | R | R | HR | — |

HR denotes that nozzle is highly recommended for this application.
R denotes that nozzle is recommended for this application.
— denotes that nozzle is not recommended for this application.

**Table 2. ISO 10625 nozzle colors**

| Flow rate at 40 PSI, gal./min* | Flow rate at 300 kPa, L/min | Color |
|---|---|---|
| 0.1 | 0.4 | Orange |
| 0.15 | 0.6 | Green |
| 0.2 | 0.8 | Yellow |
| 0.3 | 1.2 | Blue |
| 0.4 | 1.6 | Red |
| 0.5 | 2.0 | Brown |
| 0.6 | 2.4 | Gray |
| 0.8 | 3.2 | White |

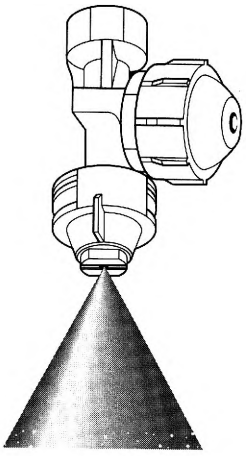
*Metric is the standard. Equivalent U.S. units are approximations only.

**Table 3. ASAE S572 classification by droplet spectra**

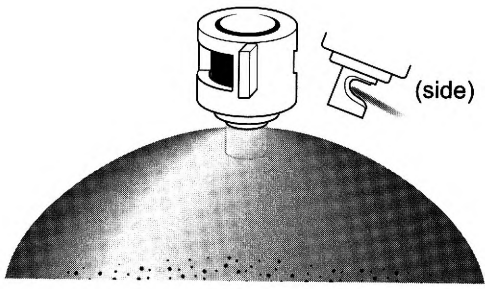
| Classification category | Symbol | Color code (in catalog tables) |
|---|---|---|
| Very fine | VF | Red |
| Fine | F | Orange |
| Medium | M | Yellow |
| Coarse | C | Blue |
| Very coarse | VC | Green |
| Extremely coarse | XC | White |

**Table 4. Droplet size spectra recommended for various pesticide uses**

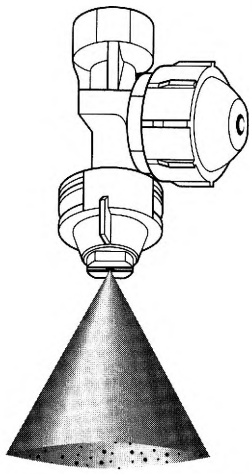
| Droplet spectrum (by ASAE S572) | Contact insecticide and fungicide | Systemic insecticide and fungicide | Postemergence contact herbicide | Postemergence systemic herbicide | Preemergence herbicide | Incorporated soil-applied pesticide |
|---|---|---|---|---|---|---|
| Very fine (VF) | .. | .. | .. | .. | .. | .. |
| Fine (F) | X | .. | .. | .. | .. | .. |
| Medium (M) | X | X | X | X | .. | .. |
| Coarse (C) | .. | X | .. | X | X | X |
| Very coarse (VC) | .. | .. | .. | .. | X | X |
| Extremely coarse (XC) | .. | .. | .. | .. | .. | X |



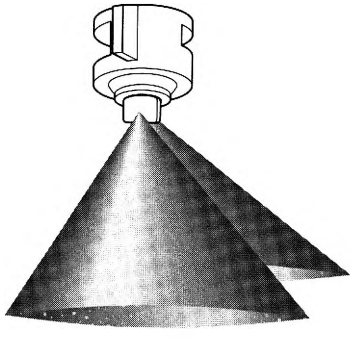
Even Flat-Fan



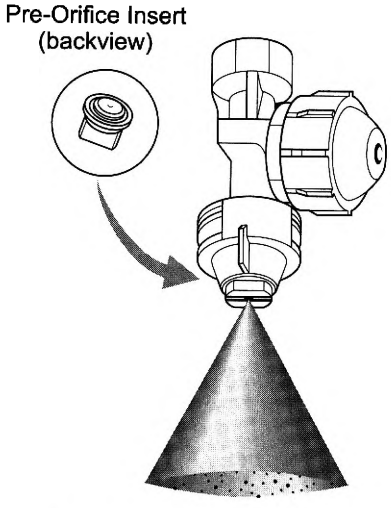

Flooding Flat-Fan (front)



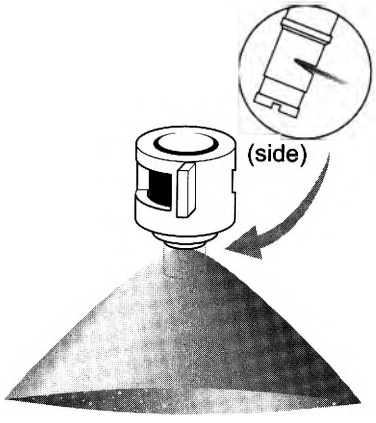
Extended-Range Flat-Fan



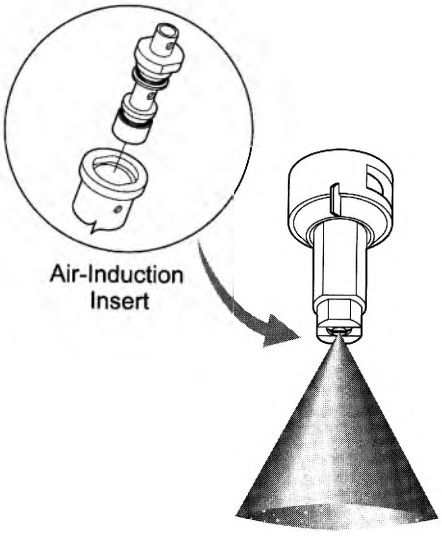
Twin-Orifice Flat-Fan



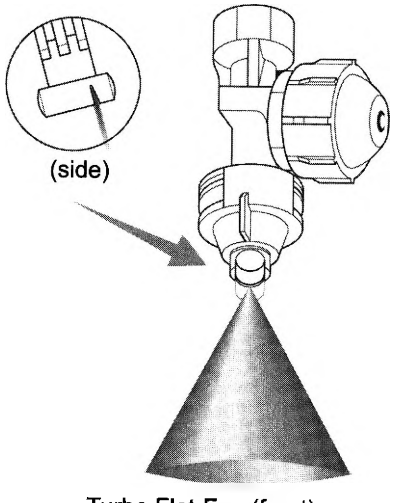

Drift-Reduction Pre-Orifice Flat-Fan




Turbo-Flood Flat-Fan




Air-Induction Flat-Fan




Turbo Flat-Fan (front)

**Figure 1. Spray nozzles that produce flat-fan spray patterns.**

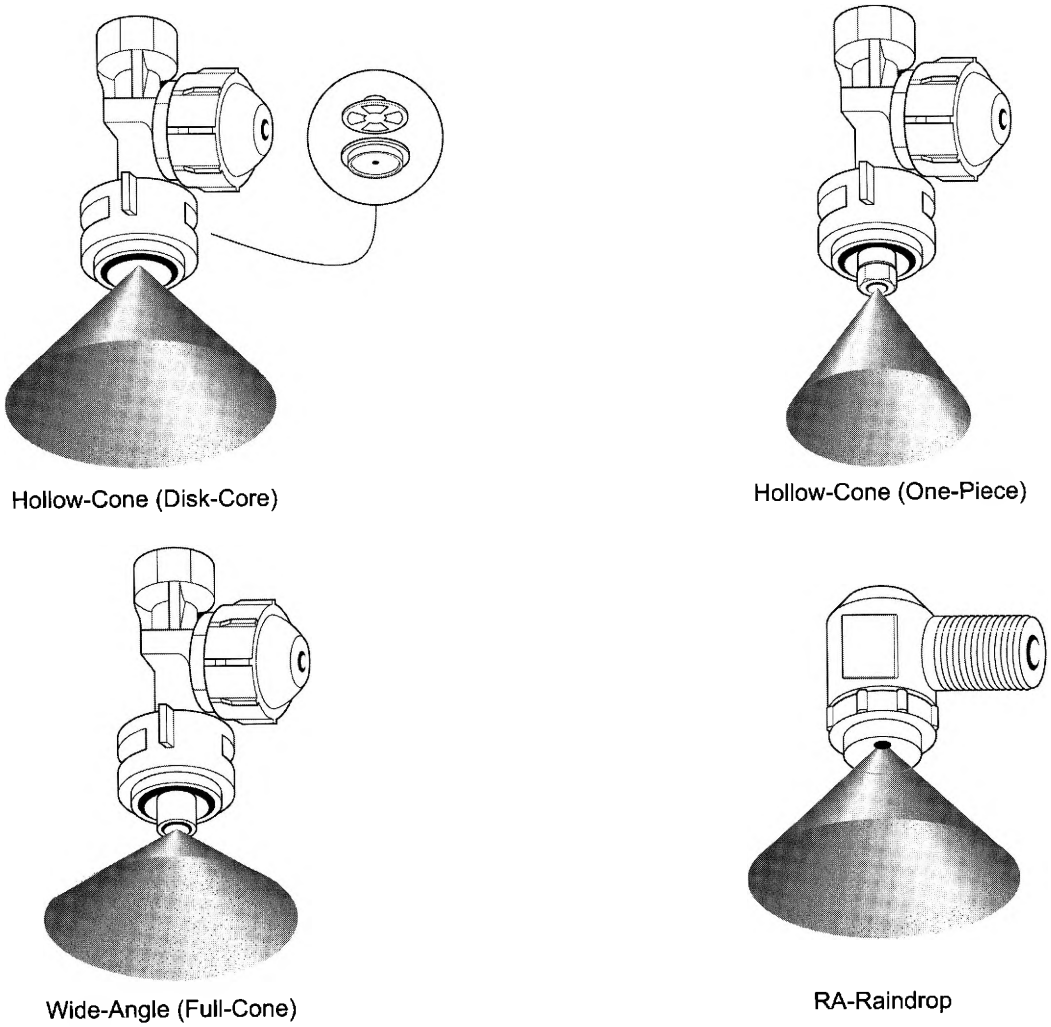



**Figure 2. Spray nozzles that produce cone spray patterns.**

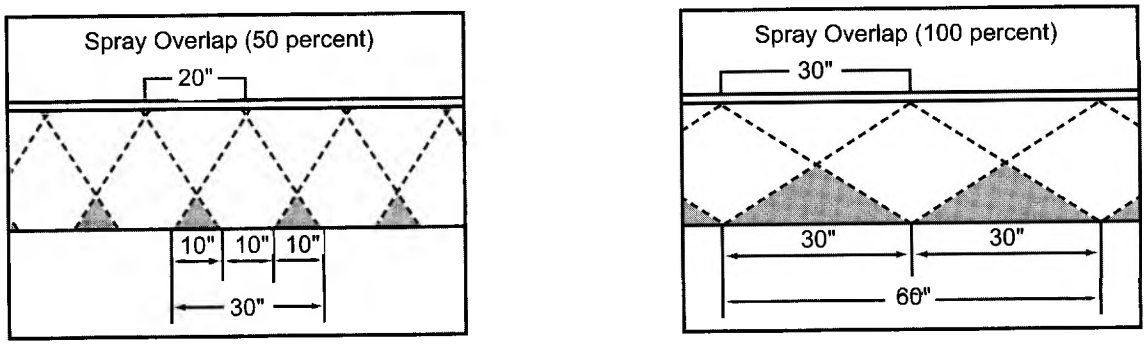



**Figure 3. Examples of 50 percent and 100 percent spray overlap.**

**Table 5. Specific gravities and conversion factors for selected solution weights**

| Solution weight, lb/gal. | Specific gravity | Conversion factor |
|---|---|---|
| 7.0 | 0.84 | 0.92 |
| 8.0 | 0.96 | 0.98 |
| 8.34[a] | 1.00 | 1.00 |
| 9.0 | 1.08 | 1.04 |
| 10.0 | 1.20 | 1.10 |
| 10.65[b] | 1.28 | 1.13 |
| 11.0 | 1.32 | 1.15 |
| 12.0 | 1.44 | 1.20 |
| 14.0 | 1.68 | 1.30 |

NOTE: This table is based on theoretical solution densities only and may vary in actual practice because of differing solution characteristics. Figures apply to flood but not Raindrop nozzles.
[a]Water.
[b]28% nitrogen.

**Table 6. Time required to obtain various travel speeds**

| | Travel time, seconds | | |
|---|---|---|---|
| Speed, MPH | 100 ft | 200 ft | 300 ft |
| 3.0 | 23 | 45 | 68 |
| 3.5 | 20 | 39 | 58 |
| 4.0 | 17 | 34 | 51 |
| 4.5 | 15 | 30 | 45 |
| 5.0 | 14 | 27 | 41 |
| 6.0 | | 23 | 34 |
| 7.0 | | 19 | 29 |
| 8.0 | | 17 | 26 |
| 9.0 | | 15 | 23 |
| 10.0 | | 14 | 20 |
| 11.0 | | | 19 |
| 12.0 | | | 17 |
| 13.0 | | | 16 |
| 14.0 | | | 15 |
| 15.0 | | | 14 |

**Table 7. Spray coverage required to obtain proper overlap of spray patterns**

| | Spray coverage (width of spray pattern) in inches at various nozzle spacings | | | | | | |
|---|---|---|---|---|---|---|---|
| Overlap (%) | 20" | 25" | 30" | 35" | 40" | 50" | 60" |
| 20 | 24 | 30 | 36 | 42 | 48 | 60 | 72 |
| 30 | 26 | 33 | 39 | 46 | 52 | 65 | 78 |
| 40 | 28 | 35 | 42 | 49 | 56 | 70 | 84 |
| 50 | 30 | 38 | 45 | 53 | 60 | 75 | 90 |
| 60 | 32 | 40 | 48 | 56 | 64 | 80 | 96 |
| 70 | 34 | 43 | 51 | 60 | 68 | 85 | 102 |
| 80 | 36 | 45 | 54 | 63 | 72 | 90 | 108 |
| 90 | 38 | 48 | 57 | 67 | 76 | 95 | 114 |
| 100 | 40 | 50 | 60 | 70 | 80 | 100 | 120 |
| 110 | 42 | 53 | 63 | 74 | 84 | 105 | 126 |
| 150 | 50 | 63 | 75 | 88 | 100 | 125 | 150 |

**Table 8. Computed spray coverage at different spray heights for various spray angles**

| Spray angle, degrees | Spray coverage (width of spray pattern) in inches at various distances from nozzle orifice | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6" | 8" | 12" | 15" | 18" | 24" | 30" | 36" | 42" | 48" | 60" |
| 15 | 1.6 | 2.1 | 3.2 | 3.9 | 4.7 | 6.3 | 7.9 | 9.5 | 11.1 | 12.6 | 15.8 |
| 25 | 2.7 | 3.5 | 5.3 | 6.6 | 8.0 | 10.6 | 13.3 | 15.9 | 18.6 | 21.2 | 26.6 |
| 30 | 3.2 | 4.3 | 6.4 | 8.0 | 9.7 | 12.8 | 16.0 | 19.3 | 22.4 | 25.9 | 32.0 |
| 40 | 4.3 | 5.8 | 8.7 | 10.9 | 13.0 | 17.4 | 21.6 | 26.2 | 30.6 | 34.9 | 42.8 |
| 45 | 4.9 | 6.6 | 9.9 | 12.4 | 14.9 | 19.8 | 24.8 | 29.8 | 34.8 | 39.7 | 49.6 |
| 50 | 5.6 | 7.4 | 11.2 | 14.0 | 16.8 | 22.4 | 28.0 | 33.6 | 39.1 | 44.8 | 56.0 |
| 60 | 6.9 | 9.2 | 13.9 | 17.3 | 20.8 | 27.6 | 34.6 | 41.6 | 48.4 | 55.4 | 69.2 |
| 65 | 7.6 | 10.2 | 15.2 | 19.1 | 22.9 | 30.5 | 38.1 | 45.8 | 53.2 | 61.0 | 76.4 |
| 70 | 8.2 | 11.2 | 16.8 | 21.0 | 25.2 | 33.6 | 42.0 | 50.4 | 59.8 | 67.2 | 84.0 |
| 73 | 8.8 | 11.8 | 17.8 | 22.2 | 26.6 | 36.4 | 44.4 | 53.2 | 62.0 | 71.0 | 88.5 |
| 75 | 9.2 | 12.3 | 18.4 | 23.0 | 27.6 | 36.8 | 46.0 | 55.2 | 64.2 | 73.5 | 92.0 |
| 80 | 10.1 | 13.4 | 20.1 | 25.2 | 30.2 | 40.2 | 50.2 | 60.4 | 72.5 | 80.8 | 100.0 |
| 90 | 12.0 | 16.0 | 24.0 | 30.0 | 36.0 | 48.0 | 60.0 | 72.0 | 84.0 | 96.0 | 120.0 |
| 100 | 14.3 | 19.1 | 28.6 | 35.8 | 42.4 | 57.2 | 71.4 | 86.0 | 100.0 | 114.6 | 143.0 |
| 120 | 20.8 | 27.8 | 41.6 | 52.0 | 62.4 | 83.0 | 104.0 | 125.0 | 145.8 | 166.2 | 208.0 |
| 140 | 33.0 | 44.0 | 65.9 | 82.4 | 98.9 | 131.9 | 164.8 | 197.8 | 230.8 | 263.8 | 329.7 |

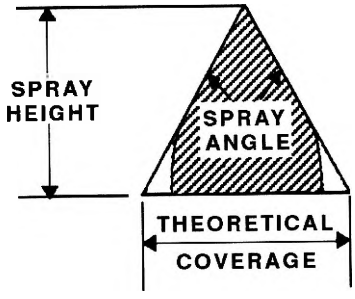



**Figure 4. Theoretical coverage of spray pattern.**

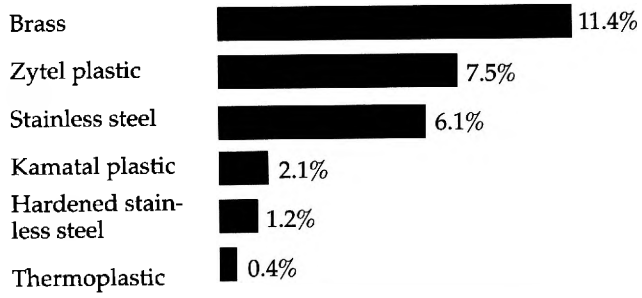



**Figure 5. Percent increase in flow rate of flat-fan spray nozzles (after 40-hour wear test).**

**Table 9. Suggested minimal spray heights for given angles**

| Spray angle | 20-inch spacing | 30-inch spacing |
|---|---|---|
| 65° | 22" to 24" | 33" to 36" |
| 73° | 20" to 22" | 29" to 36" |
| 80° | 17" to 19" | 26" to 28" |
| 110° | 10" to 12" | 14" to 18" |

**Table 10. Summary of recommended procedures for reducing drift damage**

| Recommended procedure | Example | Explanation |
|---|---|---|
| Select a nozzle type that produces coarse droplets. | Raindrop, wide-angle full-cone, flooding, Turbo, air-induction. | Use droplets as large as practical to provide necessary coverage. |
| Use the lower end of the pressure range. | Use 20 to 40 PSI for Raindrop; less than 25 PSI for other types. | Higher pressures generate many more small droplets (less than 100 microns). |
| Lower the boom height. | Use as low a boom height as possible to maintain uniform distribution. Use drops for systemic herbicides in corn. | Wind speed increases with height. Boom height a few inches lower can reduce off-target drift. |
| Increase the nozzle size. | If normal gallonage is 15 to 20 GPA, increase to 25 to 30 GPA. | Larger-capacity nozzles reduce spray depositing off target. |
| Spray when wind speeds are less than 10 MPH and moving away from sensitive plants. | Leave a buffer zone if sensitive plants are downwind. Spray buffer zone when wind changes. | More of the spray volume moves off target as wind increases. |
| Do not spray when the air is completely calm. | Absolutely calm air generally occurs in early morning or late afternoon. | Absolutely calm air reduces air mixing, and spray can move slowly downwind. |
| Use a drift-control additive when needed. | Several long-chain polymers are available. | Drift-control additives increase the average droplet size produced by the nozzles. |

**Table 11. Pressure drop for water flow through various hose sizes (in good, smooth condition)**

| | Pressure drop in pounds per square inch (10-foot lengths—without couplings) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Flow, GPM | ¼" ID | ⅜" ID | 7/16" ID | ½" ID | ⅝" ID | ¾" ID | 1" ID | 1¼" ID | 1½" ID |
| 0.2 | 0.3 | | | | | | | | |
| 0.3 | 0.6 | | | | | | | | |
| 0.4 | 1.0 | | | | | | | | |
| 0.5 | 1.4 | 0.2 | | | | | | | |
| 0.6 | 2.0 | 0.3 | | | | | | | |
| 0.8 | 3.3 | 0.5 | | | | | | | |
| 1.0 | | 0.7 | 0.3 | | | | | | |
| 1.5 | | 1.4 | 0.6 | 0.4 | | | | | |
| 2.0 | | 2.4 | 1.1 | 0.6 | | | | | |
| 2.5 | | 3.4 | 1.7 | 0.9 | | | | | |
| 3.0 | | | 2.4 | 1.2 | 0.4 | | | | |
| 4.0 | | | | 2.0 | 0.7 | | | | |
| 5.0 | | | | 2.9 | 1.0 | 0.4 | | | |
| 6.0 | | | | 4.0 | 1.4 | 0.6 | | | |
| 8.0 | | | | | 2.6 | 0.9 | 0.3 | | |
| 10 | | | | | 3.6 | 1.4 | 0.4 | | |
| 15 | | | | | | 3.0 | 0.8 | 0.3 | |
| 20 | | | | | | | 1.4 | 0.5 | 0.2 |
| 25 | | | | | | | 2.0 | 0.7 | 0.3 |
| 30 | | | | | | | 2.8 | 0.9 | 0.4 |
| 40 | | | | | | | | 1.6 | 0.5 |
| 50 | | | | | | | | 2.5 | 0.8 |
| 60 | | | | | | | | 3.4 | 1.2 |
| 70 | | | | | | | | | 1.6 |
| 80 | | | | | | | | | 2.0 |
| 90 | | | | | | | | | 2.6 |
| 100 | | | | | | | | | 3.0 |

ID = inside diameter.

**Table 12. Flow of water through schedule 40 steel pipe of various sizes (seamless or welded construction in good, clean condition)**

| | Pressure drop in pounds per square inch (10-foot lengths) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Flow, GPM | ⅛" ID | ¼" ID | ⅜" ID | ½" ID | ¾" ID | 1" ID | 1¼" ID | 1½" ID | 2" ID |
| 0.3 | 0.42 | | | | | | | | |
| 0.4 | 0.70 | 0.16 | | | | | | | |
| 0.5 | 1.1 | 0.24 | | | | | | | |
| 0.6 | 1.5 | 0.33 | | | | | | | |
| 0.8 | 2.5 | 0.54 | 0.13 | | | | | | |
| 1.0 | 3.7 | 0.83 | 0.19 | 0.06 | | | | | |
| 1.5 | 8.0 | 1.8 | 0.40 | 0.12 | | | | | |
| 2.0 | 13.4 | 3.0 | 0.66 | 0.21 | 0.05 | | | | |
| 2.5 | | 4.5 | 1.0 | 0.32 | 0.08 | | | | |
| 3.0 | | 6.4 | 1.4 | 0.43 | 0.11 | | | | |
| 4.0 | | 11.1 | 2.4 | 0.74 | 0.18 | 0.06 | | | |
| 5.0 | | | 3.7 | 1.1 | 0.28 | 0.08 | | | |
| 6.0 | | | 5.2 | 1.6 | 0.38 | 0.12 | | | |
| 8.0 | | | 9.1 | 2.8 | 0.66 | 0.20 | 0.05 | | |
| 10 | | | | 4.2 | 1.0 | 0.30 | 0.08 | | |
| 15 | | | | | 2.2 | 0.64 | 0.16 | 0.08 | |
| 20 | | | | | 3.8 | 1.1 | 0.28 | 0.13 | |
| 25 | | | | | | 1.7 | 0.42 | 0.19 | 0.06 |
| 30 | | | | | | 2.4 | 0.59 | 0.27 | 0.08 |
| 35 | | | | | | | | 0.36 | 0.11 |
| 40 | | | | | | | | 0.47 | 0.14 |
| 45 | | | | | | | | | 0.17 |
| 50 | | | | | | | | | 0.20 |
| 60 | | | | | | | | | 0.29 |
| 70 | | | | | | | | | 0.38 |
| 80 | | | | | | | | | 0.50 |
| 90 | | | | | | | | | 0.62 |
| 100 | | | | | | | | | 0.76 |

ID = inside diameter.

**Table 13. Approximate friction loss in pipe fittings in terms of equivalent feet of straight pipe**

| Pipe size, standard weight | Actual inside diameter, inches | Gate value FULL OPEN | Globe value FULL OPEN | 45° elbow | Run or standard tee | Standard elbow or run of tee reduced ½ | Standard tee through side outlet |
|---|---|---|---|---|---|---|---|
| ⅛ | 0.269 | 0.1 | 8 | 0.3 | 0.4 | 0.7 | 1.4 |
| ¼ | 0.364 | 0.2 | 11 | 0.5 | 0.6 | 1.1 | 2.2 |
| ½ | 0.622 | 0.3 | 18 | 0.7 | 1.1 | 1.7 | 3.3 |
| ¾ | 0.824 | 0.4 | 23 | 0.9 | 1.4 | 2.1 | 4.2 |
| 1 | 1.049 | 0.5 | 29 | 1.2 | 1.8 | 2.6 | 5.3 |
| 1¼ | 1.380 | 0.7 | 38 | 1.6 | 2.3 | 3.5 | 7.0 |
| 1½ | 1.610 | 0.8 | 45 | 1.9 | 2.7 | 4.1 | 8.1 |
| 2 | 2.067 | 1.1 | 58 | 2.4 | 3.5 | 5.2 | 10.4 |
| 2½ | 2.469 | 1.3 | 69 | 2.9 | 4.2 | 6.2 | 12.4 |
| 3 | 3.068 | 1.6 | 86 | 3.6 | 5.2 | 7.7 | 15.5 |
| 4 | 4.026 | 2.1 | 113 | 4.7 | 6.8 | 10.2 | 20.3 |
| 5 | 5.047 | 2.7 | 142 | 5.9 | 8.5 | 12.7 | 25.4 |
| 6 | 6.065 | 3.2 | 170 | | 10.2 | 15.3 | 31.0 |

**Table 14. Reference information for making calibration conversions**

### Standard Abbreviations

GPA = gallons per acre
GPM = gallons per minute
GPH = gallons per hour
MPH = miles per hour
OPM = ounces per minute
PSI = pounds per square inch

### Volume and Liquid Measures

8 fluid ounces = 1 cup = 236.6 ml

2 cups = 32 tablespoons = 1 pint = 473.1 ml

2 pints = 64 tablespoons = 1 quart = 946.2 ml

8 pints = 4 quarts = 1 gallon =
128 fluid ounces = 3,785 ml

### Miscellaneous Equivalents

1 acre = 43,560 square feet = 0.405 hectares

1 hectare = 2.471 acres

1 gallon per acre = 9.35 liters per hectare

1 mile = 5,280 feet = 1,610 meters =
1.61 kilometers

1 pound per square inch =
0.070 kilogram/centimeter$^2$ = 6.895 kilopascals

1 pound = 0.454 kilogram

1 inch = 2.54 centimeters

### Metric Conversion Factors

During the next few years, a gradual transition to metric (SI) units is expected in the agricultural industry. To facilitate use of these units, selected metric terms and conversion factors are given here.

| To measure | Multiply | By | To obtain |
|---|---|---|---|
| Length | inches | 25.40 | millimeters (mm) |
| | inches | 2.540 | centimeters (cm) |
| | feet | 0.3048 | meters (m) |
| | miles | 1.609 | kilometers (km) |
| Area | acres | 46.7 | square meters (m$^2$) |
| | acres | 0.4047 | hectares (ha) |
| Volume | gallons | 3.785 | cubic decimeters (dm$^3$) |
| | gallons | 3.785 | liters (L) |
| | imperial gallons | 4.546 | liters (L) |
| Flow rate | gallons/hour (GPH) | 3.785 | liters/hour (L/h) |
| | gallons/minute (GPM) | 3.785 | liters/minute (L/min) |
| Application rate | gallons/acre (GPA) | 9.353 | liters/hectare (L/ha) |
| Pressure | pounds/inch$^2$ (PSI) | 6.895 | kilopascals (kPa) |
| Speed | miles/hour (MPH) | 1.609 | kilometers/hour (KMH) |

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# 13

# Toxicity of Herbicides

Toxicity is the capacity of a substance to produce injury. Toxic effects may be immediate (acute) or accumulative (chronic), depending upon the exposure duration, the dose, and the herbicide. The toxicity of a substance varies with the animal species, age, sex, and nutritional status and with the route of exposure—through the stomach (orally), the lungs (by inhalation), or the skin (dermally). The skin and eyes are also subject to irritation caused by chemicals.

## Human Toxicity of Herbicides

Pesticide manufacturers are required to conduct acute, subacute, and chronic toxicity tests, including tests for mutagenicity, teratogenicity, and carcinogenicity. The usual expression of acute toxicity is $LD_{50}$, which is the average lethal dose in milligrams per body weight in kilograms (mg/kg) required to kill 50 percent of a test population. Toxicity tests are conducted on experimental animals, such as white rats, mice, and rabbits.

To make mg/kg more meaningful, the following factors are given to convert mg/kg to ounces per pound (oz/lb) for a 100-pound person and a 187-pound person:

mg/kg x 0.0016 = oz/100 lb
mg/kg x 0.0030 = oz/187 lb

Because toxicity depends upon body weight, the amount of chemical considered lethal for a child is less than the amount for an adult. And conversely, it takes more to kill a large animal than a small one.

The categories of toxicity are given in Table 1. The herbicide label indicates the extent of toxicity by the signal word(s) it carries. The signal word on the label applies to the most serious method or route of exposure. For example, if a herbicide has an acute oral $LD_{50}$ of 368 (which triggers the signal word "Warning") and an acute dermal $LD_{50}$ of > 2,000 (which triggers "Caution") and is severely and irreversibly corrosive to the eyes (which warrants "Danger"), then the label signal word is "Danger."

### Danger–Poison

Herbicides with the active ingredient endothall or paraquat carry the signal word "Danger" plus a skull and crossbones. Endothall is available in liquid form as Aquathol K and Hydrothol 191. Paraquat is available as Gramoxone Max and Cyclone Max.

These herbicide labels carry the following precautions: The user is advised to wear goggles or a face shield, rubber gloves, and a rubber apron when working with concentrates and to avoid breathing spray mists.

### Danger–Corrosive

The signal words "Danger–Corrosive" indicate the risk of irreversible eye or skin burns. This warning is usually accompanied by a recommendation that the user wear goggles or a face shield, especially when handling concentrates. The label also may call for wearing rubber gloves and an apron when handling or mixing concentrates or adjusting equipment. The first-aid statement states, "In case of contact with eyes, immediately flush eyes with plenty of water for at least 15 minutes and **get medical attention promptly.**" If the contact is with the skin, the label calls for washing with plenty of water. If skin irrita-

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*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

**Table 1. Toxicity categories of herbicides**

| Toxicity category | Label signal words | 4-hr exposure $LC_{50}$* (mg/L) | Acute oral $LD_{50}$ (mg/kg) | Acute dermal $LD_{50}$ (mg/kg) | Acute inhalation $LC_{50}$* (mg/L) |
|---|---|---|---|---|---|
| I. High | Danger–Poison | ≤ 0.05 | < 50 | < 200 | < 0.2 |
| II. Moderate | Warning | 0.05–0.5 | 50–500 | 200–2,000 | 0.2–2 |
| III. Low | Caution | 0.5–2 | 500–5,000 | 2,000–5,000 | 2–20 |
| IV. Very low | Caution | > 2 | > 5,000 | > 5,000 | > 20 |

*$LC_{50}$ = concentration of pesticide, in milligrams per liter of air space, required to kill 50 percent of a test population.

tion occurs, medical attention should be sought. Herbicides in this category are listed in Table 2.

### WARNING

"Warning" is the signal word used for herbicides containing an active ingredient that is moderately toxic through oral, dermal, or inhalation exposure. The labels state, under "Hazardous to Humans," "May be fatal or harmful if swallowed, inhaled, or absorbed through the skin." The following herbicides contain such a warning:

**Bromoxynil**
Buctril 2EC, Buctril + atrazine, Moxy, etc.

**Diquat**
Reward, Weedtrine-D

**Glufosinate**
Liberty, Liberty ATZ

"Warning" also appears as a signal word for herbicides with label statements indicating that they can cause eye or skin irritation or burns or may be harmful if swallowed, inhaled, or absorbed through the skin. Herbicides in this category are listed in Table 3.

Most of these herbicide labels state, "Do not get into eyes or on skin." If skin or eye contact occurs, the labels advise washing the contacted areas thoroughly for 15 minutes and calling a physician in case of eye contact. All herbicide labels must include a section describing the appropriate personal protective equipment that should be worn by applicators and handlers.

Any herbicide that does not have a "Danger" or "Warning" signal word has "Caution" on the label. "Caution" indicates that the product has low oral, dermal, and inhalation toxicity and has little or no irritability to either the eyes or the skin.

**Table 2. Herbicides labeled with the signal words "Danger–Corrosive" or "Danger–Poison"**

| Trade name | Common name |
|---|---|
| Accent Gold | nicosulfuron + rimsulfuron + flumetsulam + clopyralid |
| Aquathol | endothall |
| Assure II | quizalofop |
| Butoxone 200 | 2,4-DB amine |
| Butyrac 200 | 2,4-DB amine |
| Cobra | lactofen |
| Confront | triclopyr + clopyralid |
| Curtail | clopyralid + 2,4-D |
| Devrinol 2E | napropamide |
| Garlon 3A | triclopyr amine |
| Gramoxone Max | paraquat |
| Hydrothol 191 | endothall |
| IntRRo | alachlor |
| Keystone | acetochlor + atrazine |
| Keystone LA | acetochlor + atrazine |
| Laddok S-12 | bentazon + atrazine |
| Many | 2,4-D amine |
| MCPA Amine | MCPA |
| Reflex | fomesafen |
| Shotgun | atrazine + 2,4-D |
| Sonalan (HFP or 10G) | ethalfluralin |
| Storm | acifluorfen + bentazon |
| Ultra Blazer | acifluorfen |
| Velpar L | hexazinone |
| Weedone 638 | 2,4-D acid + ester |

**Table 3. Herbicides labeled with the signal word "Warning"**

| Trade name | Common name |
|---|---|
| Alanap-L | naptalam |
| Banvel, Sterling | dicamba |
| Buctril, Moxy, Bromox, etc. | bromoxynil |
| Define | flufenacet |
| Extreme | imazethapyr + glyphosate |
| Flexstar | fomesafen |
| G-Max Lite, Guardsman Max | dimethenamid-P + atrazine |
| Goal | oxyfluorfen |
| Harness | acetochlor + safener |
| Hornet WDG | flumetsulam + clopyralid |
| Liberty | glufosinate |
| Lightning | imazethapyr + imazapyr |
| MCPA esters | MCPA |
| Outlook | dimethenamid-P |
| Poast | sethoxydim |
| Pramitol | prometon |
| Pursuit DG | imazethapyr |
| Resource | flumiclorac |
| Reward, Weedtrine-D | diquat |
| Ronstar | oxadiazon |
| Select | clethodim |
| Super Brush | 2,4-D + dicamba + dichlorprop |
| Surpass | acetochlor |

## Environmental Toxicity of Herbicides

The "Environmental Hazards" section of the label includes statements regarding toxicity to fish and wildlife, and the user is urged to be especially careful in this regard. Herbicides that state they are toxic to fish or wildlife contain the active ingredients bromoxynil, propachlor, or others:

**Bromoxynil**
Buctril 2EC, Moxy, Bromox, etc.
Buctril + atrazine 3WDL

**Others**
Goal (oxyfluorfen)
Gramoxone Max (paraquat)
Reward, Weedtrine-D (diquat)

Some herbicide labels carry the statement "Toxic to Fish." These include certain esters of phenoxy and pyridinoxy-phenoxy herbicides, the dinitroaniline herbicides, and miscellaneous others. All herbicide labels warn the user to keep the product out of lakes and streams.

**Dinitroanilines (DNAs)**
Balan (benefin)
Prowl, Pendimax (pendimethalin)
Sonalan, Curbit (ethalfluralin)
Many (trifluralin)

**DNA mixes**
Pursuit Plus (pendimethalin + imazethapyr)

**Oxy-phenoxy esters**
Fusilade DX 2EC (fluazifop)
Fusion 2.56EC (fluazifop + fenoxaprop)
Horizon 2000 2.56EC (fenoxaprop + fluazifop)

**Phenoxy esters**
(There are many phenoxy herbicide products.)
Crossbow 3EC
Esteron 3.8EC, 99
Garlon 4E
MCPA ester
Patron LV4EC, LV6EC
Patron 170, Brushout 3.7E

Other herbicides, such as **Aim** (carfentrazone), contain warnings stating that they are very toxic to algae and moderately toxic to fish. The potential for contaminating groundwater with pesticides has prompted the addition of groundwater statements on several pesticide labels, especially products containing atrazine, simazine, flufenacet, dimethenamid, acetochlor, alachlor, metolachlor, or metribuzin. Table 4 lists herbicides carrying label statements cautioning the user to handle the herbicides in a manner that minimizes the potential for groundwater contamination.

**Table 4. Herbicides carrying label statements about groundwater contamination**

| Trade name | Common name | Trade name | Common name |
|---|---|---|---|
| 2,4-D Amine (many) | 2,4-D Amine | Harness | acetochlor |
| AAtrex, Atrazine | atrazine | Harness Xtra | acetochlor + atrazine |
| Accent Gold | rimsulfuron + nicosulfuron + flumetsulam + clopyralid | Hornet WDG | flumetsulam + clopyralid |
| | | Hyvar X, XL | bromacil |
| Authority | sulfentrazone | IntRRo | alachlor |
| Axiom | flufenacet + metribuzin | Keystone, Keystone LA | acetochlor + atrazine |
| Balance Pro | isoxaflutole | Krovar | bromacil + diuron |
| Banvel | dicamba | Laddok S-12 | atrazine + bentazon |
| Basagran | bentazon | Liberty ATZ | glyphosate + atrazine |
| Basis Gold | rimsulfuron + nicosulfuron + atrazine | Lightning | imazethapyr + imazapyr |
| | | Lumax, Lexar | *S*-metolachlor + atrazine + mesotrione |
| Bicep II Magnum, Bicep Lite II Magnum | *S*-metolachlor + atrazine | Marksman | dicamba + atrazine |
| | | Micro-Tech | alachlor |
| Boundary | *S*-metolachlor + metribuzin | Northstar | primisulfuron + dicamba |
| Buctril + atrazine | bromoxynil + atrazine | Outlook | dimethenamid-P |
| Camix | *S*-metolachlor + mesotrione | Pathway | picloram + 2,4-D |
| Canopy XL | sulfentrazone + chlorimuron | Princep | simazine |
| Celebrity Plus | nicosulfuron + dicamba + diflufenzopyr | Python | flumetsulam |
| | | ReadyMaster ATZ | glyphosate + atrazine |
| Clarity | dicamba | Sencor | metribuzin |
| Define | flufenacet | Sequence | *S*-metolachlor + glyphosate |
| Degree | acetochlor | Shotgun | atrazine + 2,4-D |
| Degree Xtra | acetochlor + atrazine | Sim-Trol | simazine |
| Distinct | dicamba + diflufenzopyr | Spartan | sulfentrazone |
| Domain | flufenacet + metribuzin | Spirit | primisulfuron + prosulfuron |
| Dual II Magnum | *S*-metolachlor | Steadfast ATZ | nicosulfuron + rimsulfuron + atrazine |
| Epic | isoxaflutole + flufenacet | | |
| Expert | *S*-metolachlor + atrazine + glyphosate | Stinger | clopyralid |
| | | Storm | bentazon + acifluorfen |
| FieldMaster | acetochlor + atrazine + glyphosate | Surpass | acetochlor |
| | | TopNotch | acetochlor |
| FirstRate, Amplify | chloransulam | Tordon 101 | picloram + 2,4-D |
| FulTime | acetochlor + atrazine | Tordon K | picloram |
| G-Max Lite, Guardsman Max | dimethenamid-P + atrazine | Tordon RTU | picloram + 2,4-D |
| | | Ultra Blazer | acifluorfen |

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# 14

# Weed Resistance to Herbicides

Herbicide-resistant weed biotypes continue to plague farmers across much of Illinois. Biotypes are populations within a species that possess characteristics not common to the species as a whole. In this case, the "uncommon characteristic" is resistance to a particular herbicide. Understanding how herbicide resistance develops is an important initial step in designing effective weed-management strategies that deter the selection for resistant biotypes. Table 1 provides a listing of weed species in Illinois that have biotypes resistant to particular herbicide families.

The occurrence of herbicide-resistant weeds has increased during the past decade, but the first reports of herbicide-resistant weeds were documented as early as the 1950s, when dandelion and wild carrot biotypes were reported to be resistant to 2,4-D. Triazine-resistant common groundsel was first reported in 1968 in Washington; and, to date, resistance to triazine herbicides has been documented most frequently. Worldwide, more than 180 weed species have been reported to possess resistance to one family of herbicides or another.

The terminology used when discussing herbicide resistance can be confusing. The most common terms are defined as follows:

**Herbicide resistance:** Resistance is the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type.

**Herbicide tolerance:** Tolerance is the inherent ability of a species to survive and reproduce after herbicide treatment.

Let's examine these definitions more closely. Notice in the definition of resistance, the word "plant" is used, whereas "species" is used in the definition of tolerance. Stated another way, a resistant plant is a member of a species that, as a whole, is susceptible to the herbicide. The resistant plant is a **biotype** of that species that is no longer susceptible to the herbicide. Tolerance implies the species has never been susceptible to the herbicide.

Other terms related to herbicide resistance include the following:

**Cross-resistance:** Resistance to a herbicide the plant may not have been previously exposed to but that has a mode or site of action similar to the original herbicide.

**Multiple-resistance:** Resistance to more than one class of herbicides with very different modes or sites of action in which more than one basis for resistance may be involved.

The following examples may help to eliminate confusion about these terms. A producer who has grown continuous corn on the same field for many years has used atrazine (a photosynthesis-inhibiting herbicide) each year for weed control. He or she notices that in recent years the control of common lambsquarters has been poor. The local Extension educator collects seed from the common lambsquarters and, during the winter, confirms that the weed is **resistant** to atrazine. The producer then decides to switch to simazine (another photosynthesis inhibitor) the following year and again finds the control of common lambsquarters to be poor. Further investigation reveals that the common lambsquarters is also resistant to simazine. Because the plants are resistant to both atrazine and simazine, they are said to exhibit **cross-resistance**. The next year, the producer decides to use a post-emergence application of Clarity (a growth-regulating herbicide) to control the common lambsquarters, and

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once again poor control results. Investigations reveal that the common lambsquarters is also resistant to Clarity, a situation that is defined as **multiple-resistance**. A documented example of multiple-resistance is a biotype of waterhemp from western Illinois. This biotype has demonstrated resistance to such herbicide families as the acetolactate synthase (ALS) inhibitors, triazines (atrazine, simazine), and protoporphyrinogen oxidase (PPO) inhibitors. If these forms of resistance were ranked from least difficult to most difficult to control with herbicides, the order would be resistant < cross-resistant < multiple-resistant.

## Origin of Resistance

To avoid the development of herbicide-resistant weeds, one should have a basic understanding of how a resistant weed population develops. Two mechanisms have been proposed: the mutation theory and the natural-selection theory.

The mutation theory postulates that a genetic mutation occurs within a plant following the application of a herbicide and that this mutation confers resistance to the plant. There is little evidence to support this theory, and it is disregarded by most scientists as a valid explanation for the development of resistance to herbicides.

The natural-selection theory is widely regarded as the most plausible explanation for the development of resistance. The theory states that herbicide-resistant biotypes have always existed at extremely low numbers within particular weed species. When a herbicide effectively controls the majority of susceptible members of a species, only those plants that possess a resistance trait can survive and produce seed for future generations.

This theory of resistance development has several parallels to Darwin's theory of survival of the fittest. Biological organisms (humans, plants, animals, etc.) exhibit a wide range of diversity. No two people are exactly the same, and plants likewise show extreme diversity. The plants that are in a population with characteristics enabling them to survive under a wide range of environmental and other adverse conditions will be the ones to produce seed that maintains these survival characteristics. The plants less adapted do not survive, and hence only the fittest plants produce seed. Plants that possess characteristics (such as resistance to herbicides) that are not common to the entire species are referred to as "biotypes." The characteristics possessed by resistant biotypes that confirm herbicide resistance will be presented later in the chapter.

What then is meant by "selection pressure" in regard to herbicide-resistant weeds? Herbicides are used to control a wide spectrum of weeds. By controlling susceptible members of a weed population, we are essentially using herbicides as agents to select for biotypes that are naturally resistant to the herbicide. When most of the susceptible members of a weed population are controlled, the resistant biotypes are able to continue growing and eventually produce seed. The seed from the resistant biotypes ensures that the resistance trait carries into future seasons. If the same herbicide is used year after year, or several times during a single season, the resistant biotypes continue to thrive, eventually outnumbering the normal (susceptible) population. In other words, relying on the same herbicide (or herbicides with the same site of action) for weed control creates selection pressure that favors the development of herbicide-resistant weeds.

The development of a herbicide-resistant weed population can be summarized by the following principle: *The appearance of herbicide-resistant weeds is the consequence of using a herbicide with a single site of action year after year or of repeating applications of a herbicide during the growing season to kill a specific weed species not controlled by any other herbicide or in any other manner.* This principle has three key components:

1. A herbicide with a single site of action.
2. Repeated use of the same herbicide.
3. The absence of other control measures.

By understanding these components and developing weed-control systems with them in mind, producers can greatly reduce the probability that herbicide-resistant weeds will develop in their fields.

## Basis for Weed Resistance

What occurs within a resistant plant that allows it to survive after a herbicide application? What characteristics do the resistant plants possess that the susceptible plants lack? Two mechanisms have been identified that account for the majority of observed cases of herbicide resistance:

1. **Alterations in the target site of the herbicide.** A herbicide has a specific site within the plant where it acts to disrupt a particular plant process or function. If this target site is somewhat altered, the herbicide molecule may be unable to exert its phytotoxic action effectively. Thus far, most cases of herbicide resistance have involved alterations in the herbicide target site. Examples include resistance to triazine (atrazine, simazine, and others), ALS-inhibiting herbicides (imazaquin, chlorsulfuron, and others), and ACCase-inhibiting herbicides (sethoxydim, fenoxaprop, and others).

2. **Enhanced metabolism of the herbicide**. Metabolism within the plant is one mechanism a plant uses to detoxify a foreign compound such as a herbicide. A weed with an enhanced ability to metabolize a herbicide can potentially inactivate it before it can reach its site of action within the plant. A triazine-resistant biotype of velvetleaf from Maryland has been identified that possesses an enhanced ability to metabolize the herbicides atrazine and simazine. Generally, as stated earlier, weed resistance to triazine herbicides is attributed to alterations in the target site of the herbicide. This velvetleaf biotype, however, possesses an enhanced enzyme activity that rapidly metabolizes the herbicide to nonphytotoxic forms.

## Management Strategies to Minimize Herbicide-Resistant Weeds

The best solution for minimizing herbicide-resistant weeds is to prevent their selection. In the past, as new weed problems were discovered, the usual solution has been to develop new herbicides. Today, the high cost of developing a new herbicide makes good management practices the best method for dealing with herbicide-resistant weeds. The following management strategies may help deter the development of herbicide resistance:

- Scout fields regularly to identify resistant weeds. Respond quickly to changes in weed populations to restrict the spread of plants that may have developed resistance.
- Rotate herbicides with different sites of action. Do not make more than two consecutive applications of herbicides with the same site of action against the same weed unless other effective control practices are included in the management system. Consecutive applications can be single applications in 2 years or two split applications in 1 year.
- Apply herbicides in tank-mixed, prepackaged, or sequential mixtures that include multiple sites of action. Both herbicides in the mixture must have substantial activity against potentially resistant weeds, as well as similar soil persistence.
- As new herbicide-resistant and herbicide-tolerant crops become available, their use should still not result in more than two consecutive applications of herbicides with the same site of action against the same weed unless other effective practices are included in the management system.
- Combine mechanical control practices (such as rotary hoeing, cultivating, and even hand weeding) with herbicide treatments for a near-total weed-control program.
- Clean tillage and harvest equipment before moving from fields infested with resistant weeds to fields that are not infested.
- Railroads, public utilities, highway departments, and similar organizations using total-vegetation-control programs should be encouraged to use practices that do not lead to the development of herbicide-resistant weeds. Resistant weeds resulting from areas of total vegetation control frequently spread to cropland. Chemical companies, state and federal agencies, and farm organizations can help in this effort.

Several criteria may be used to diagnose a herbicide-resistant weed problem correctly:

- All other causes of herbicide failure have been eliminated.
- Other weeds on the herbicide label (besides the one in question) were controlled effectively.
- The field has a history of continuous or repeated use of the same herbicide or herbicides with the same site of action.
- The weed species was controlled effectively in the past. Weed control in the field has been based entirely on herbicides without mechanical control.

With these management strategies and diagnosis criteria in mind, how does one go about correctly identifying a resistant weed population? We know that initially resistant weed biotypes are present at extremely low frequencies within a particular population. It stands to reason, then, that because of such a low initial frequency, resistance will most likely be first noticed within a particular field as a few individual weeds that were not controlled. In other words, resistant weeds do not usually infest an entire field within 1 year. Typically, the resistant weed population is initially confined to small, isolated patches. If the same herbicide-control program is followed repeatedly, these patches begin to encompass a larger proportion of the field until finally the resistant weeds appear as the dominant species. So a producer who encounters an entire field of resistant weeds has most likely had a resistant population in the field for more than 1 year.

How can the spread of resistant weeds be confined? Early identification of the problem, using the information provided in this chapter, ultimately proves beneficial. A hypothetical scenario may help put all these pieces of the resistance puzzle together.

A producer has grown continuous corn for the last 10 years on a particular 40-acre farm, using atrazine at the highest allowable rate each year to control broadleaf weeds. While scouting this field during the growing season, the producer notices several lambsquarters in a small patch (say 30 feet in diameter) but observes that all other weed species commonly encountered in this field were effectively controlled. The producer knows that atrazine has been used continuously on this field for 10 years and realizes that, because all other weeds that are susceptible to atrazine were controlled, this may be the early stages of the development of a triazine-resistant population of lambsquarters. With this in mind, the producer eradicates the small patch of lambsquarters by hand hoeing so that no seed will be produced by those plants. Needless to say, the producer should develop an alternative weed-management program for future years that does not rely exclusively on triazine herbicides.

Tables 2 and 3 list herbicides and herbicide premixes according to their respective sites of action. Table 2 further divides the herbicides into those that possess higher or lower potential to select for resistant weeds. The classifications are based primarily on two criteria: how extensively a particular herbicide active ingredient is used in Illinois and scientific documentation of resistance to a particular herbicide or herbicide site of action.

**Table 1. Weed species in Illinois that include herbicide-resistant biotypes and the herbicide families to which these biotypes are resistant**

| Weed species | | |
|---|---|---|
| Common name | Scientific name | Resistant to herbicide family(ies) |
| common lambsquarters | *Chenopodium album* | triazine |
| smooth pigweed | *Amaranthus hybridus* | triazine, ALS inhibitors |
| kochia | *Kochia scoparia* | triazine, ALS inhibitors |
| common waterhemp | *Amaranthus rudis* | triazine, ALS inhibitors, PPO inhibitors |
| eastern black nightshade | *Solanum ptycanthum* | ALS inhibitors |
| giant ragweed | *Ambrosia trifida* | ALS inhibitors |
| common ragweed | *Ambrosia artemisiifolia* | ALS inhibitors |
| common cocklebur | *Xanthum strumarium* | ALS inhibitors |
| shattercane | *Sorghum bicolor* | ALS inhibitors |
| giant foxtail | *Setaria faberi* | ACCase inhibitors, ALS inhibitors |
| horseweed | *Conyza canadensis* | glyphosate (suspected) |

**Table 2. Resistance potential of herbicides according to site of action**

| Higher potential | Lower potential |
|---|---|
| **Inhibitors of acetyl-CoA carboxylase (ACCase)** | **Inhibitors of microtubule assembly** |
| *Aryloxyphenoxy propionates* | *Dinitroanilines* |
| fenoxaprop (Horizon) | benefin (Balan) |
| fluazifop (Fusilade DX) | pendimethalin (Prowl, Pendimax) |
| quizalofop (Assure II) | trifluralin (Treflan, others) |
| *Cyclohexanediones* | **Synthetic auxins—specific site unknown** |
| clethodim (Select) | *Phenoxys* |
| sethoxydim (Poast Plus) | 2,4-D (Weedone, others) |
| **Inhibitors of acetolactate synthase (ALS)** | MCPA (various) |
| *Sulfonylureas* | MCPP (various) |
| chlorimuron (Classic) | *Benzoic acids* |
| chlorsulfuron (Telar) | dicamba (Banvel, Clarity) |
| foramsulfuron (Option) | *Carboxylic acids* |
| halosulfuron (Permit) | clopyralid (Stinger) |
| nicosulfuron (Accent) | fluroxypyr (Starane) |
| primisulfuron (Beacon) | picloram (Tordon) |
| prosulfuron (Peak) | triclopyr (Garlon) |
| rimsulfuron (Resolve) | **Inhibitors of Photosystem I** |
| sulfometuron (Oust) | *Bipyridiliums* |
| thifensulfuron (Harmony GTXP) | diquat (Reward) |
| tribenuron (Express) | paraquat (Gramoxone Max) |
| *Imidazolinones* | **Inhibitors of EPSP synthase** |
| imazamox (Raptor) | glyphosate (Roundup, Touchdown, others) |
| imazapic (Cadre, Plateau) | **Inhibitors of glutamine synthetase** |
| imazapyr (Arsenal) | glufosinate (Liberty, Finale) |
| imazaquin (Scepter) | **Inhibitors of lipid biosynthesis, not via ACCase** |
| imazethapyr (Pursuit) | *Thiocarbamates* |
| *Triazolopyrimidines* | butylate (Sutan+) |
| cloransulam (FirstRate, Amplify) | EPTC (Eradicane) |
| flumetsulam (Python) | **Bleaching: Inhibitors of diterpene synthesis** |
| **Inhibitors of photosynthesis at Photosystem II** | *Isoxazolidinones* |
| *Triazines* | clomazone (Command) |
| ametryn (Evik) | **Bleaching: Inhibitors of 4-HPPD** |
| atrazine (AAtrex, others) | *Isoxazoles* |
| prometon (Pramitol) | isoxaflutole (Balance Pro) |
| simazine (Princep) | mesotrione (Callisto) |
| *Triazinones* | |
| hexazinone (Velpar) | |
| metribuzin (Sencor) | |
| *Uracils* | |
| bromacil (Hyvar) | |
| terbacil (Sinbar) | |

**Table 2. Resistance potential of herbicides according to site of action (cont.)**

| Higher potential | Lower potential |
|---|---|
| **Inhibitors of photosynthesis at Photosystem II —same site, different binding behavior**<br>*Ureas*<br>diuron (Karmex, Direx)<br>linuron (Lorox)<br>tebuthiuron (Spike)<br><br>**Inhibitors of protoporphyrinogen oxidase**<br>*Diphenylethers*<br>acifluorfen (Ultra Blazer)<br>fomesafen (Flexstar, Reflex)<br>lactofen (Cobra, Phoenix)<br><br>*N-phenylphthalimides*<br>flumiclorac (Resource)<br>flumioxazin (Valor)<br><br>*Aryl triazinones*<br>carfentrazone (Aim)<br>sulfentrazone (Authority, Spartan) | **Inhibitors of photosynthesis at Photosystem II —same site, different binding behavior**<br>*Nitriles*<br>bromoxynil (many)<br><br>*Benzothiadiazoles*<br>bentazon (Basagran)<br><br>**Unknown**<br>*Chloroacetamides*<br>acetochlor (Degree, Harness, TopNotch)<br>alachlor (IntRRo, Micro-Tech, Partner)<br>dimethenamid (Outlook)<br>S-metolachlor (Dual Magnum, Dual II Magnum)<br><br>*Oxyacetamides*<br>flufenacet (Define) |

**Table 3. Premix herbicides with at least one herbicide component with a high potential for contributing to weed resistance**

| Photosynthetic inhibitors | ALS inhibitors |
|---|---|
| **atrazine**<br>Basis Gold (atrazine + *rimsulfuron** + *nicosulfuron)*<br>Bicep Lite II Magnum (atrazine + *S-metolachlor)*<br>Bicep II Magnum (atrazine + *S-metolachlor)*<br>Buctril + atrazine (atrazine + bromoxynil)<br>Bullet (atrazine + *alachlor)*<br>Degree Xtra (atrazine + *acetochlor)*<br>Expert (atrazine + *acetochlor* + *glyphosate)*<br>FieldMaster (atrazine + acetochlor + *glyphosate)*<br>FulTime (atrazine + *acetochlor)*<br>Guardsman Max (atrazine + *dimethenamid-P)*<br>Harness Xtra (atrazine + *acetochlor)*<br>Keystone (atrazine + *acetochlor)*<br>Keystone LA (atrazine + *acetochlor)*<br>Laddok S-12 (atrazine + *bentazon)*<br>Liberty ATZ (atrazine + *glufosinate)*<br>Lexar (atrazine + *S-metolachlor* + *mesotrione)*<br>Lumax (atrazine + *S-metolachlor* + *mesotrione)*<br>Marksman (atrazine + *dicamba)*<br>ReadyMaster ATZ (atrazine + *glyphosate)*<br>Shotgun (atrazine + *2,4-D)*<br>Steadfast ATZ (atrazine + *nicosulfuron* + *rimsulfuron)*<br><br>**metribuzin**<br>Boundary (metribuzin + *S-metolachlor)* | **imazethapyr**<br>Extreme (imazethapyr + *glyphosate)*<br>Lightning (imazethapyr + imazapyr*)*<br>Pursuit Plus (imazethapyr + *pendimethalin)*<br><br>**chlorimuron**<br>Canopy EX (chlorimuron + tribenuron)<br>Canopy XL (chlorimuron + *sulfentrazone)*<br>Synchrony XP (chlorimuron + thifensulfuron)<br><br>**flumetsulam**<br>Accent Gold (flumetsulam + *clopyralid* + nicosulfuron + rimsulfuron)<br>Hornet (flumetsulam + *clopyralid)*<br><br>**foramsulfuron**<br>Equip (foramsulfuron + iodosulfuron)<br><br>**imazaquin**<br>Backdraft (imazaquin + *glyphosate)*<br>Squadron (imazaquin + *pendimethalin)*<br><br>**thifensulfuron**<br>Basis (thifensulfuron + rimsulfuron)<br>Harmony Extra (thifensulfuron + tribenuron)<br>Synchrony XP (thifensulfuron + chlorimuron)<br><br>**primisulfuron**<br>Northstar (primisulfuron + *dicamba)*<br>Spirit (primisulfuron + prosulfuron)<br><br>**rimsulfuron**<br>Accent Gold (rimsulfuron + flumetsulam + nicosulfuron + *clopyralid)*<br>Basis (rimsulfuron + thifensulfuron)<br>Basis Gold (rimsulfuron + nicosulfuron + *atrazine)*<br>Steadfast (rimsulfuron + nicosulfuron)<br>Steadfast ATZ (rimsulfuron + nicosulfuron + *atrazine)*<br><br>**nicosulfuron**<br>Accent Gold (nicosulfuron + rimsulfuron + flumetsulam + *clopyralid)*<br>Basis Gold (nicosulfuron + rimsulfuron + *atrazine)*<br>Celebrity Plus (nicosulfuron + *dicamba* + *diflufenzopyr)*<br>Steadfast (nicosulfuron + rimsulfuron)<br>Steadfast ATZ (nicosulfuron + rimsulfuron + *atrazine)* |

*Herbicides in italics have a different site of action. For example, Bicep II Magnum contains a triazine component (atrazine) and a nontriazine component *(S-metolachlor)*.

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# 15

# Herbicide Persistence and How to Test for Residues in Soils

## Topics of Interest

- Factors affecting herbicide persistence
- Herbicide families that persist in soils
- Precautions to avoid herbicide carryover
- Testing soils for herbicide residues
- Practices to overcome herbicide residues in soils

## Factors Affecting Herbicide Persistence

Herbicides are applied to the soil in hopes of obtaining season-long weed control. It is desirable for the chemicals to control weeds during the season of application, but they should not remain long enough to affect subsequent crop growth. The length of time that a herbicide remains active in the soil is called "soil persistence" or "soil residual life." Anything that affects the disappearance or breakdown of a herbicide affects persistence. Many factors determine the length of time herbicides persist. Most factors fall into three categories: soil factors, climatic conditions, and herbicidal properties. These categories strongly interact with one another.

Herbicides vary in their potential to persist in the soil. Some herbicide families that have persistent members include the triazines, uracils, phenylureas, sulfonylureas, dinitroanilines, pigment inhibitors, imidazolinones, and certain plant-growth regulators. Table 1 lists several common herbicides in these groups. Table 2 lists the soil persistence of some common herbicides.

## Soil Factors

The soil factors affecting herbicide persistence fit into three categories: physical, chemical, and microbial. Soil composition is a physical factor that measures the relative amounts of sand, silt, and clay (the soil texture) and the organic-matter content of the soil. Chemical properties of the soil include pH, cation-exchange capacity (CEC), and nutrient status. The microbial aspects of the soil environment include the type and abundance of soil microorganisms present.

Soil composition affects herbicide phytotoxicity and persistence through adsorption, leaching, and volatilization. Generally, soils high in clay, organic matter, or both have a greater potential for herbicide carryover because there is increased adsorption to soil colloids, with a corresponding decrease in leaching and loss through volatilization. This "tie-up" results in decreased initial plant uptake and herbicidal activity. Therefore, more herbicide is held in reserve to be released later, potentially injuring susceptible future crops.

Some herbicides, principally the triazines (atrazine and simazine), are particularly affected by soil pH, an important part of the soil chemical makeup. Lesser amounts of these herbicides are adsorbed or held to soil colloids at higher soil pH, so they remain in the soil solution. Herbicides in the soil solution are available for plant uptake. Chemical breakdown and microbial breakdown, two major herbicide degradation processes, are often slower in soils of higher pH. So although decreased adsorption of triazine herbicides occurs in soils of higher pH, there is also less breakdown activity. Therefore, these herbicides are more available for plant uptake for a longer period on soils of higher pH. Certain members of the sulfonylurea group (chlorsulfuron

*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

**Table 1. Herbicide families with their persistent members**

**S-triazines**
atrazine (AAtrex, Atrazine)
hexazinone (Velpar)
prometon (Pramitol)
simazine (Princep)

**Dinitroanilines**
benefin (Balan)
oryzalin (Surflan)
pendimethalin (Pendimax, Prowl)
prodiamine (Barricade)
trifluralin (Treflan, Tri-4, Trilin)

**Others**
bensulide (Betasan, Prefar)
clomazone (Command)
tebuthiuron (Spike)

**Phenylureas**
diuron (Karmex, Direx)

**Uracils**
bromacil (Hyvar-X)
terbacil (Sinbar)

**Imidazolinones**
imazapyr (Arsenal)
imazaquin (Scepter)
imazethapyr (Pursuit)

**Sulfonylureas**
chlorimuron (Classic)
chlorsulfuron (Telar)
nicosulfuron (Accent)
primisulfuron (Beacon)
prosulfuron (Peak)
sulfometuron (Oust)

**Plant-growth regulators**
clopyralid (Stinger)
picloram (Tordon)
triclopyr (Garlon)

and chlorimuron) can also persist in higher-pH soils because rates of chemical breakdown are decreased. Low pH affects the persistence of clomazone and the imidazolinones (imazaquin and imazethapyr). Soil pH has little effect on the persistence of other herbicides.

Research shows that various nutrients and cations in the soil affect both herbicide activity and degradation. The CEC, principally a function of clay type and organic-matter content, is directly involved in herbicide adsorption. Some herbicides are more available in the presence of certain cations, whereas others may be tied up and therefore unavailable. The literature indicates that there is much variation in the effect that cations and nutrients can have on herbicide activity and breakdown, depending on soil composition, nutrient type and concentration, and chemistry of the herbicide.

Soil microorganisms are partially responsible for the breakdown of many herbicides. The types of microorganisms and their relative amounts determine how quickly decomposition occurs. Soil microbes require certain environmental conditions for optimal growth and utilization of any pesticide. Factors that affect microbial activity are temperature, pH, oxygen, and mineral nutrient supply. Usually, a warm, well-aerated, fertile soil with a medium soil pH is most favorable for microorganisms and hence herbicide breakdown.

## Climatic Conditions

The climatic variables involved in herbicide degradation are moisture, temperature, and sunlight. Herbicide degradation rates generally increase with increased temperature and soil moisture because both chemical and microbial decomposition rates increase under conditions of higher temperature and moisture. Cool, dry conditions slow degradation, causing greater carryover potential. If winter and spring conditions are wet and mild, herbicide persistence is less likely.

Sunlight is another important factor in herbicide degradation. Photodegradation, or decomposition by light, has been reported for many herbicides. The dinitroanilines (trifluralin and pendimethalin) are sensitive to light degradation. They may be lost when surface-applied if they remain for an extended time without rainfall. Therefore, degradation is accelerated on very sunny days. This sensitivity to light and loss by volatility are primary reasons for soil incorporation.

## Herbicidal Properties

Finally, the chemical properties of a herbicide affect its persistence. Important factors include water solubility, soil adsorption, vapor pressure, and susceptibility to chemical and microbial alteration or degradation. The water solubility of a herbicide helps to determine its leaching potential. Leaching occurs when a herbicide is dissolved in water and moves down through the soil profile. Herbicides that readily leach may be carried away or carried to rooting zones of susceptible

**Table 2. Soil persistence of some common herbicides applied at labeled Illinois use rates**

| 1 month | 1 to 3 months | 3 to 12 months | More than 12 months |
|---|---|---|---|
| 2,4-D | acetochlor (Degree, Harness, Surpass, TopNotch) | atrazine (AAtrex) | bromacil (Hyvar) |
| glufosinate (Liberty) | alachlor (IntRRo, Micro-Tech) | benefin (Balan) | chlorsulfuron (Telar) |
| glyphosate (Roundup, Touchdown, many) | ametryn (Evik) | bensulide (Betasan, Prefar) | imazapyr (Arsenal) |
| MCPA | bentazon (Basagran) | bromoxynil (Buctril, many) | picloram (Tordon) |
| | butylate (Sutan+) | chlorimuron (Classic) | prometon (Pramitol) |
| | DCPA (Dacthal) | clomazone (Command) | sulfometuron (Oust) |
| | dimethenamid (Outlook) | diuron (Direx, Karmex) | tebuthiuron (Spike) |
| | EPTC (Eptam, Eradicane) | ethalfluralin (Curbit, Sonalan) | |
| | flumetsulam (Python) | fomesafen (Flexstar, Reflex) | |
| | foramsulfuron (Option) | hexazinone (Velpar) | |
| | halosulfuron (Permit) | imazaquin (Scepter) | |
| | lactofen (Cobra, Phoenix) | imazethapyr (Pursuit) | |
| | linuron (Lorox) | isoxaflutole (Balance Pro) | |
| | mesotrione (Callisto) | oryzalin (Surflan) | |
| | metolachlor (Dual II Magnum) | pendimethalin (Pendimax, Prowl) | |
| | metribuzin (Sencor) | primisulfuron (Beacon) | |
| | naptalam (Alanap) | prodiamine (Barricade) | |
| | siduron (Tupersan) | pronamide (Kerb) | |
| | | prosulfuron (Peak, in Spirit) | |
| | | simazine (Princep) | |
| | | sulfentrazone (Authority, Spartan, in Canopy XL) | |
| | | terbacil (Sinbar) | |
| | | trifluralin (Treflan, many) | |

plants. Herbicide leaching is determined not only by a herbicide's water solubility but also by its ability to adsorb to soil particles. Additionally, soil texture and available soil water affect herbicide leaching. Herbicides that are low in water solubility, are strongly adsorbed to soil colloids, and exist in dry soils are less likely to leach and have a greater potential to persist.

The vapor pressure of a herbicide determines its volatility, the process of changing from a liquid or a solid to a gas. Volatility increases with temperature. Volatile herbicides such as the thiocarbamates (EPTC, butylate) must be incorporated immediately to avoid gaseous losses. These herbicides are less likely to persist than herbicides with low vapor pressures.

Herbicides may be rapidly decomposed by microorganisms in the soil if the right kinds and numbers of microorganisms are present and if soil conditions are favorable for their growth. However, herbicides vary greatly in their susceptibility to microbial decomposition. For example, microbial degradation of 2,4-D occurs very quickly in the soil, whereas microbial degradation of atrazine is slow.

Chemical decomposition is dependent not only on the chemistry of the herbicide (how susceptible it is to chemical breakdown) but also on soil and climatic factors. Chemical breakdown of a herbicide involves reactions such as hydrolysis, oxidation, and reduction. The occurrence of these reactions and the rates at which they take place vary with soil type and climatic conditions. These reactions, along with microbial degradation, are important processes in the decomposition of herbicides.

## Avoiding Herbicide Carryover

There are several ways to avoid herbicide carryover problems. First, always apply the correct rate of any herbicide for your specific soil type and weed problem. This means applying the lowest labeled rate of the chemical consistent with obtaining the desired effect.

To accomplish this goal, accurate acreage determination, accurate chemical measurement, proper sprayer calibration, and uniform application are essential. Always read the label before applying any herbicide.

The method and time of application can be important in avoiding herbicide carryover. Incorporation dilutes herbicides; however, herbicides that have the potential to persist longer than desired will more likely remain longer if incorporated than if surface-applied without incorporation. Incorporating the herbicide makes it less susceptible to loss by volatilization and photodegradation. In addition, an incorporated herbicide is immediately exposed to soil particles and may be tied up temporarily through adsorption and later released. Decreased environmental losses (volatilization and photodegradation) and increased adsorption favor herbicide carryover. Banded herbicide applications can reduce carryover potential because less total herbicide is applied than in a broadcast application. Postemergence and late soil applications have greater potential than earlier applications for being present the following season.

The amount of tillage affects herbicide persistence. Tillage encourages herbicide decomposition indirectly through increased microbial and chemical breakdown. Minimum-till and no-till, which leave crop residue on the soil surface, also tend to leave a greater concentration of herbicide near the surface zone. Persistent herbicides present in this concentrated zone may affect susceptible crops. In addition, higher rates of herbicides are often used in reduced-tillage systems to maximize weed control and adjust for greater amounts of crop residues. If a herbicide-carryover problem already exists, some tillage to dilute the chemical may help.

Herbicide combinations may reduce the risk of carryover problems. By tank-mixing two or more herbicides, you may reduce the application rates of those products that can potentially cause problems and at the same time broaden the weed-control spectrum.

Herbicides may interact with one another or with other pesticides and may enhance crop injury when applied in the same year or in consecutive years. For example, a soybean crop may tolerate a certain level of atrazine carryover. However, if another photosynthetic inhibitor, such as metribuzin, is applied to soybeans after atrazine-treated corn, injury is more likely.

Plants absorb herbicides from the soil in which they are growing. Persistence may be reduced if the herbicide is metabolized (broken down) by the plant or if the plant containing the absorbed herbicide is harvested and removed from the field. Plant extraction of the herbicide from the soil may not be an important factor under most situations, but it has been used in some cases to help remove persistent herbicides from treated soils.

Finally, the selection of a tolerant rotational crop or variety helps minimize carryover problems. Quite often, economics dictates crop rotation; however, there are varietal differences that might affect the likelihood of serious crop injury. For example, some soybean varieties are more sensitive to the triazine herbicides than others and should not be used if the potential for triazine injury exists. Also, as a general rule, smaller-seeded crops and varieties have a greater potential for injury from persistent herbicides than do larger-seeded species.

Many variables interact in predicting herbicide persistence. Factors involved in the degradation of herbicides include many soil, climatic, and herbicidal properties. The potential for herbicide carryover problems can be reduced by using the appropriate rates and accurate timing of proper application methods. The use of selective tillage, herbicide combinations, and tolerant crops and varieties can also help reduce the risk of crop injury.

## Testing for Herbicide Residues

If herbicide carryover is suspected, a soil chemical test or a bioassay can be used to determine if harmful levels of herbicide are present. Chemical analysis can be expensive, so a bioassay conducted either in the suspect field or in a warm, sunny indoor location (such as a greenhouse) may be more feasible. These tests help predict potential herbicide-residue problems so the grower can make better decisions about crop rotation, herbicide selection, planting date, and other cultural practices.

## Soil Collection and Preparation

With the lab analysis or indoor bioassay, proper sampling of soil is the first step. The procedures for submitting a soil for laboratory analysis and for conducting an indoor bioassay are similar. These guidelines should be followed:

1. In early to midspring or before planting time, collect representative soil samples from the suspect field. Take samples from several locations in the field. For the bioassay or laboratory analysis, take 15 to 20 soil cores and combine them to make a composite sample. This sample should represent no more than 15 to 20 acres. Enough areas must be sampled to avoid missing locations with high herbicide-residue content. Take separate samples from areas where excessive residues are suspected, such as sprayer

turnaround points and end rows. Do not mix these samples with the others. Sample the soil to a 6-inch depth, and divide the samples into two sections for greater accuracy—those from 0 to 3 inches and those from 3 to 6 inches. Be sure to mark on the bags the depths from which the samples came. About 8 pounds of soil (about 4 quarts) are needed for each bioassay and 2 pounds of soil (about 1 quart) for each laboratory analysis.

2. Sample an area that is not suspect for use as a "check" soil. This soil may be taken from a nearby fencerow or another untreated area. Keep this sample separate from the others. Many laboratories require a check soil.
3. Submit the samples to the laboratory as soon as possible after sampling. If bioassays are to be performed, they should be run on the soil samples as soon as possible after they have been obtained from the field. If samples cannot be assayed immediately, store the soil in a refrigerator or freezer that is not used for food. If samples are stored in a warm environment, herbicide residue may decrease with time.

## Bioassay

The bioassay can help predict potential crop injury. The test is inexpensive and can be done with a few simple supplies. A bioassay does not measure the amount of herbicide residue present in the soil, but it may indicate whether or not enough residue is present to injure a sensitive crop.

### Field Bioassay

A field bioassay is conducted by planting one or more strips of a species sensitive to the suspect herbicide in the field. This procedure can be done in the fall or spring, but it is more accurate when performed closer to the planting of the intended crop. Before planting the desired crop, allow the test plants to grow and develop symptoms of injury from any herbicide residues. Plant the strips in several locations, if possible, and include an area that is most suspect and an area that can serve as a check. Choose an appropriate species for the bioassay, such as one of the more sensitive ones listed in this chapter. Include several species of differing sensitivity for greater accuracy.

### Indoor Bioassay

The procedures for conducting an indoor bioassay vary, depending on what herbicide residue is of concern. However, for the indoor bioassay, the procedures for soil collection and preparation are the same.

1. For an indoor bioassay, collect the samples and allow them to air dry if needed until they can be worked readily. Do not overdry. If the soil is cloddy, crush the clods into pieces (the size of a pea or smaller). If the soil contains a high amount of clay, the addition of coarse sand (50 percent by volume) improves its physical condition. If sand is added, mix it thoroughly with the soil.
2. Tin cans, milk cartons, and cottage cheese containers are appropriate containers in which a bioassay can be conducted. Punch holes in the bottoms of the containers to allow water drainage. Fill two or more containers (a set) with soil from each sample. Additional containers increase the accuracy of the test. Place the soil samples obtained from depths of 0 to 3 inches in one set of containers; and, in another set, place the soil obtained from depths of 3 to 6 inches. Follow this procedure for the composite sample and the sample taken from areas where excessive residues are expected. In addition, fill a final set of containers with the check soil.

## Testing for Specific Herbicide Groups

### Triazine Residues

For suspected carryover from triazine herbicides, such as atrazine and Princep (simazine), an oat plant bioassay works best. Place about 15 oat seeds in each container of soil and cover the seeds with about 1 inch of soil. Wet the soil with water, but do not saturate it.

Place the containers in a warm location (70° to 75°F) where they can receive ample light. Sunlight is esential for the development of the plant as well as for inducing symptoms of triazine injury. The container should be watered as needed.

Injury symptoms should become apparent within 10 to 14 days after emergence. Triazine injury is characterized by chlorosis (yellowing), then necrosis (browning) of leaf tissue. As injury symptoms start at the leaf tip and develop toward the base, a comparison with the plants in the check soil is essential.

If injury appears on the oats, enough herbicide residue may be present to injure a susceptible crop. Planting a more tolerant crop is suggested. In general, the order of susceptibility from most to least susceptible to triazine herbicides is as follows:

Ryegrass > Alfalfa > Oats > Wheat > Soybean > Sorghum > Corn

### DNA Residues

If residues from dinitroaniline (DNA) herbicides, such as Treflan (trifluralin) or Prowl, Pendimax (pendime-

thalin), are suspected, a different assay technique is used. A sorghum or corn root bioassay is relatively quick and easy to perform.

Wrap a number of sorghum or corn seeds in a moist paper towel and store them at room temperature for 2 to 3 days. This procedure allows the seed to imbibe water and germinate. Once the seed has germinated, carefully place three to five seeds into containers with the suspect soil and the check soil. Cover the seeds with soil to a depth of about 1 inch and leave them for 10 to 14 days, depending on the air temperature. Water the plants as needed but do not saturate the soil.

At the end of the period of 10 to 14 days, carefully remove the plants and observe the root formation. DNA herbicides inhibit root development. Symptoms include stunted plants, stubbed roots, inhibited root-hair development, thickened hypocotyls on broadleaf species, and leaves that fail to unroll. If the plants in the suspect soil display any of these symptoms in comparison to the check plants, DNA residues may be present at concentrations high enough to injure susceptible crops. In general, the order of susceptibility from most to least susceptible to DNA herbicides is as follows:

Annual rye > Oats > Sorghum > Corn > Wheat > Alfalfa > Soybean

### Imazaquin, Imazethapyr, and Chlorimuron Residues

Imazaquin, the active ingredient in Scepter and a component of Backdraft; imazethapyr, the active ingredient in Pursuit and a component of Pursuit Plus, Extreme, and Lightning; and chlorimuron, the active ingredient in Classic and a component of Canopy EX and Synchrony XP, have the same mode of action. These herbicides affect root and shoot growth and development. Symptoms of plant injury include inhibited root development, stunted plants, and interveinal chlorosis or leaf striping. Therefore, a sorghum or corn-root bioassay performed according to the procedure outlined for suspected DNA residue is appropriate. Corn is more sensitive to imazaquin, and sorghum is more sensitive to imazethapyr and chlorimuron. In addition to making root observations, look for stunted shoot growth and interveinal chlorosis or yellowing. Bioassay plants should be grown for 14 to 21 days. The order of crop susceptibility from most to least susceptible to imazaquin, imazethapyr, and chlorimuron is as follows:

*Imazaquin*: Canola > Alfalfa = Corn = Sunflower > Sorghum > Oats > Wheat > Soybean

*Imazethapyr*: Canola > Sorghum > Sunflower > Oats > Wheat > Corn > Alfalfa > Soybean

*Chlorimuron*: Canola > Alfalfa > Sunflower > Sorghum > Corn > Oats > Wheat > Soybean

Introduction and commercialization of Clearfield (CL) corn hybrids resistant to the imidazolinone herbicides provide producers with a viable option for corn production in fields suspected of having soil-residue levels (carryover) of imidazolinone herbicides high enough to cause injury to conventional hybrids. If bioassay results show residue levels of imidazolinone herbicides are high enough to cause potential injury to conventional hybrids, you may consider planting a Clearfield hybrid if corn is the rotational crop of choice.

### Command (Clomazone) Residues

Clomazone, the active ingredient in Command, inhibits the production of photosynthetic pigments in susceptible plants, causing them to emerge lacking green color (that is, they are white). Lower levels of Command injury may appear as a chlorosis or mild bleaching of the plants. Oats or wheat can be used to detect Command residues using the same procedure as was outlined for detecting triazine residues. Bioassay plants should be grown for 10 days to 2 weeks. Susceptible plants that are exposed to significant levels of Command residues will be white, while untreated or tolerant plants will be green. Keep in mind that oats and wheat are usually more susceptible than corn to injury from Command. The order of susceptibility from most to least susceptible to Command residues is as follows:

Oats = Wheat = Alfalfa > Sunflower = Sorghum = Corn > Soybean

### Other Residues

Bioassays may be made for other herbicides using similar techniques. If the site of action of a specific herbicide is known, then a procedure for detecting the herbicide can be developed. For example, if the herbicide is a root meristematic inhibitor (that is, if it stops cell division in the roots), then a root bioassay is the appropriate test. If the herbicide inhibits photosynthesis, then injury symptoms first appear in the leaves. Choose a species that is moderately susceptible to the suspected herbicide, and always include a check soil. Wheat and oats are very good indicator plants for many herbicides but may be more sensitive than the desired crop. Include several species in the bioassay

to give a better range of susceptibility. The desired rotational crop is a good bioassay plant to include.

## Laboratory Analysis

Laboratory analysis involves extracting herbicide from the soil with the use of specialized equipment to detect very small amounts. The amount is usually expressed in parts of herbicide per million parts of soil (ppm). This measurement can be transposed into pounds of herbicide active ingredient per acre (lb a.i./A) if we assume that an acre of soil weighs 1 million pounds in the top 3 inches and 2 million pounds in the top 6 inches. For a soil sample taken to a 3-inch depth, 1 ppm = 1 lb/A of residue. For a soil sample taken to a 6-inch depth, 1 ppm = 2 lb/A of residue.

A lab report of 0.2 ppm atrazine, then, means that there is 0.2 pound of atrazine per acre if the samples were taken to a 3-inch depth, and 0.4 pound per acre if taken to a 6-inch depth.

The location and concentration of the chemical depend on the herbicide used, the soil type, whether the ground was tilled, and the amount of rainfall since application. In most medium-textured soils (silt loams, silty clay loams, sandy clay loams), the herbicide remains primarily in the top 3 inches unless there was excessive rainfall, the ground was plowed, or the herbicide was deeply incorporated. If the soil has a high sand content (coarse texture), then herbicide leaching may be greater. Movement of the herbicide from the surface soil zone by tillage or by rainfall decreases the likelihood of crop injury. The risk of injury is greater when the herbicide residue is concentrated in the top 3 inches rather than distributed throughout a 6-inch soil depth. Therefore, it is best to sample in two separate sections, from 0 to 3 inches and from 3 to 6 inches.

Whether parts per million or pounds of active ingredient of herbicide per acre is used, it is difficult to translate these units of measure into potential crop injury. Many variables affect crop susceptibility or tolerance, including soil type, crop sensitivity, and environmental conditions after planting. Crop injury is more likely on more coarsely textured soils or under cool, wet weather conditions. Additionally, high soil pH increases the potential of triazine or chlorimuron injury. General guidelines are provided in Table 3 although you are cautioned that crop injury may still occur below these levels.

Laboratories may differ in available tests and in the prices for analysis. The cost can range from $20 to $200 per sample for herbicide analysis. Most laboratories can analyze a sample and have the results in 5 to 7 days. Contact your local Extension office for more information on laboratory selection.

## Correcting for Herbicide Residues

If the lab test or bioassay indicates a potential herbicide-residue problem, several steps can be taken.

1. First select a tolerant crop or variety. This selection depends on what herbicide is of concern. Check current herbicide labels for more information on crop tolerance.
2. Tillage can help dilute herbicide in a problem field.
3. Plant the field that concerns you last. Delaying planting allows more time for the herbicide to dissipate.
4. If the triazine herbicides or chlorimuron is suspect, be sure to check the soil pH and adjust your management practices accordingly.
5. If imazaquin or imazethapyr is suspect, check for low soil pH (< 5.5). Liming would both benefit crop growth and minimize carryover of these herbicides.

Soil bioassays or laboratory tests are not 100 percent accurate in predicting herbicide-residue problems. Crop response to herbicide residue depends on various factors, including species and variety, soil type, and environmental conditions after planting. So, predicting crop injury is often difficult. However, using a soil chemical test or bioassay can help in deciding whether a potential problem exists and in choosing the appropriate crop or variety.

**Table 3. General guidelines for interpreting laboratory soil analysis**

| Herbicide | Safe level* | | Crop |
|---|---|---|---|
| | Parts per billion | Parts per million | |
| Triazine | 150–250 | 0.150–0.250 | Soybean |
| | 40–100 | 0.04–0.100 | Alfalfa |
| | 60–150 | 0.06–0.150 | Oats |
| | 75–180 | 0.075–0.180 | Wheat |
| Dinitroaniline | 100–200 | 0.100–0.200 | Corn |
| | 200–300 | 0.200–0.300 | Wheat |
| Clomazone | 50–200 | 0.050–0.200 | Corn |
| | 15–100 | 0.015–0.100 | Wheat, alfalfa |
| Imazaquin | 2–10 | 0.002–0.010 | Corn |
| | 10–30 | 0.010–0.030 | Wheat |
| Imazethapyr | 10–30 | 0.010–0.030 | Corn |
| | 4–15 | 0.004–0.015 | Sorghum |
| Chlorimuron | 1–2 | 0.001–0.002 | Corn |
| | 2–5 | 0.002–0.005 | Wheat |

*Due to differences in herbicide availability from the soil, "safe" values for herbicide residues differ according to soil type. Low-range values are for coarsely textured soils with low levels of organic matter; higher-range values are for finely textured soils with higher levels of organic matter. 1 ppm = 1,000 ppb.

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# 16

# Pesticide Licensing Requirements and Restricted Use Pesticide List

This chapter is intended to provide clear information about the pesticide licensing requirements in Illinois. It also includes a comprehensive list of restricted use pesticides (RUPs) and information about the associated record-keeping requirements. For more information about pesticide safety and the other pesticide, worker, and environmental laws in Illinois, contact your local University of Illinois Extension office. Extension's publication, *Pesticide Applicator Training Manual: General Standards*, is a valuable resource that addresses pesticide laws and safety issues in detail.

## Illinois Pesticide Act Licensing Requirements

A pesticide license is required of everyone who purchases or applies RUPs. The words "Restricted Use Pesticide" are prominently displayed on every RUP label. Also, anyone applying any restricted or general use pesticides in the course of employment must have a license. However, a person using a general use pesticide on his or her own or rented property is exempt.

The Illinois Department of Agriculture certifies and licenses those individuals who use pesticides in outdoor environments and in the production of agricultural commodities. University of Illinois Extension provides training and study materials for those seeking licenses. This chapter provides licensing information for these uses.

The Illinois Department of Public Health certifies and licenses individuals using pesticides in and on manufactured structures. Such uses include nuisance bird control, rodent control, wood treatment, and insect control. This chapter does not cover licensing for structural pest control.

### Types of Licenses

**Private Applicator License.** This license is required for people applying restricted use pesticides to produce an agricultural commodity on property they own or control. In addition, private applicators must pass the Grain Fumigation certification exam in order to fumigate their own grain bins. For information concerning private applicator and grain fumigation training and testing, contact your local University of Illinois Extension office. The current fee is $15 for a 3-year license, with or without Grain Fumigation certification.

**Pesticide Dealer License.** An individual selling restricted use pesticides must be licensed. Also, an individual selling nonrestricted use (general use) pesticides for the production of an agricultural commodity in containers with capacities equal to or greater than 2½ gallons or 10 pounds must be licensed. A test, license, and fee are required for certification. Also, pesticide dealers are required to keep records of RUP sales for 2 years. Commercial Applicators and Structural Pest Control Operators are exempt from the test and fee, but they must register as dealers. The current fee is $100 for a 1-year license; however, the certification exam is valid for a period of 3 years if no lapse in licensure occurs.

**Commercial Applicator and Operator Licenses.** These licenses are required for individuals who use or supervise the use of general or restricted use pesticides for hire. The current fee is $45 for a 1-year applicator's license or $35 for a 1-year operator's license; however, the certification exam is valid for a period of 3 years if no lapse in licensure occurs.

**Public Applicator and Operator Licenses.** These licenses are required for individuals who use or

*The information in this chapter is provided for educational purposes only. Product trade names have been used for clarity, but reference to trade names does not imply endorsement by the University of Illinois; discrimination is not intended against any product. The reader is urged to exercise caution in making purchases or evaluating product information.*

*Label registrations can change at any time. Thus the recommendations in this chapter may become invalid. The user must read carefully the entire, most recent label and follow all directions and restrictions. Purchase only enough pesticide for the current growing season.*

supervise the use of pesticides classified for general or restricted use as an employee of a state agency, municipality, or other duly constituted governmental agency or unit. There is no license fee, and the certification exam is valid for a period of 3 years if no lapse in licensure occurs.

**Commercial Not-for-Hire Applicator and Operator Licenses.** These licenses are required for individuals who use or supervise the use of pesticides classified for general or restricted use for any purpose on property of an employer when such activity is a requirement of the terms of employment and the application is limited to property under the employer's sole control. There is no license fee, and the certification exam is valid for a period of 3 years if no lapse in licensure occurs.

### Applicator vs. Operator License

**Applicators.** An applicator (Commercial, Public, or Commercial Not-for-Hire) is the person in an organization who has the responsibility for all pesticide purchasing, storage, handling, and use. Each organization must have at least one person licensed as an applicator at each facility location. The categories included on the applicator's license dictate the areas where a company may legally apply pesticides. An applicator is usually an owner, a supervisor, or a foreman. An applicator may use pesticides or supervise the use of pesticides by licensed operators.

The following are requirements for obtaining an applicator license:

- *Pass a General Standards exam.* An applicant must pass either the General Standards or the Aerial General Standards exam; each exam has 100 questions.
- *Pass one or more category exams.* The category exams are 50-question tests on specialized topics. Category selection depends on the sites where the company uses pesticides.
- *Complete the license application.* After you pass your exam(s), an application will be sent to you. Submit the completed application to the Illinois Department of Agriculture within 90 days. If 90 days elapse, you must retest.
- *Provide a certificate of insurance.* In addition to paying the license fee, commercial applicators must provide a certificate of insurance with proper coverage. The insurance requirements will be sent to you along with your application.

**Operators.** An operator (Commercial, Public, or Commercial Not-for-Hire) is a person who uses pesticides at the job site. The operator's license is tied directly to a specific applicator's license. An individual cannot be licensed as an operator unless he or she works with a properly licensed applicator. Furthermore, an operator may not legally apply pesticides for any other applicator. The operator can apply pesticides only under the direct supervision of the applicator and can apply pesticides only to areas covered by the applicator's license. Supervision and direction of operators by an applicator is interpreted to mean that the applicator must be in daily contact with the operators. If the applicator is out of town or not available, the operator may not legally apply pesticides.

The following are requirements for obtaining an operator's license:

- *Provide proof of employment by a licensed applicator.* Operators must be employed and supervised by a currently licensed applicator.
- *Pass a General Standards exam.* An applicant must pass either the General Standards exam or the Aerial General Standards exam; each exam has 100 questions.
- *Complete the license application.* After you pass your exam, an application will be sent to you. Submit the application to the Illinois Department of Agriculture within 90 days. If 90 days elapse, you must retest.

### Technical Categories of Licensure

Each technical category is designed to cover pesticide use requiring specific professional knowledge. An applicator's license must include all categories necessary to cover a company's entire range of pesticide use. Many applicators need multiple categories on licenses.

- *Aquatic pest control.* Pesticide use for weed control in standing or running water.
- *Demonstration and Research.* Pesticide use during research or during the teaching of proper pesticide and equipment use.
- *Field Crop pest control.* Pesticide use in corn, soybeans, small grains, forages, grasslands, etc.
- *Forest pest control.* Pesticide use in forests, forest nurseries, and forest seed-producing areas.
- *Fruit Crop pest control.* Pesticide use in fruit and nut crops.
- *Grain Facility pest control.* Noncommercial pesticide use in and around grain elevators or similar grain-holding facilities, conveyances, and transportation facilities.
- *Grain Fumigation pest control.* Pesticide use by private applicators to treat stored grain on their own property.
- *Livestock pest control.* Pesticides applied to livestock or livestock barns.
- *Mosquito control.* Insecticides applied to control mosquitoes.
- *Ornamental pest control.* Pesticide use on trees, shrubs, and ornamental plantings.

- *Plant Management pest control.* Pesticide use on portable plants used for interior landscaping and environmental enhancement.
- *Regulatory pest control.* Pesticide use by government employees involved in the control of regulated pests.
- *Right-of-Way pest control.* Chemical weed control on noncrop sites, such as on parking lots, along roads, in access rights-of-way, and in fence lines.
- *Sewer Line Root control.* Chemical control of roots in sewer lines.
- *Seed Treatment.* Pesticide use on seeds.
- *Soil Fumigation.* Pesticide use for soil fumigation.
- *Turf pest control.* Pesticide use on turf areas and sod farms.
- *Vegetable Crop pest control.* Pesticide use in vegetable crops.

### Important Addresses and Phone Numbers

**Commercial Clinic Preregistration and Study Material Information.** The University of Illinois Extension Pesticide Applicator Training (PAT) Program is responsible for pesticide training as well as answering questions regarding training availability, schedules, clinic preregistration, and study materials. For information, contact

University of Illinois
Pesticide Safety Education Program
1201 S. Dorner Dr.
Urbana, IL 61801
Phone: (800)644-2123 or (217)244-2123
Fax: (217)244-3469

**License Information.** The Illinois Department of Agriculture is responsible for pesticide testing and licensing, and agency representatives can answer questions regarding required exams, category requirements, and license availability. For information, contact

IDA/Bureau of Environmental Programs
P.O. Box 19281
State Fairgrounds
Springfield, IL 62794-9281
(217)785-2427(TDD)
(800)641-3934

or

IDA/Bureau of Environmental Programs
9511 Harrison St.
Des Plaines, IL 60016
(847)294-4343

**Structural Pest Control.** The Illinois Department of Public Health is responsible for training and testing in category 7 (indoor, structural pest control). For information about this category of licensure, contact

IDPH/Division of Environmental Health
525 W. Jefferson, 3rd Floor
Springfield, IL 62761
(217)782-4674

## Restricted Use Pesticides

In 1972, amendments to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) provided the legal mechanism for restricting the use of certain pesticides. The U.S. Environmental Protection Agency (USEPA), confronted with the enormous task of reviewing all registered pesticides, proposed to classify pesticides by their active ingredients, subdividing each active ingredient into its various formulations or uses. This classification system provided the USEPA with more flexibility to restrict some, but not all, products containing the same active ingredient. The process was called classification by regulation. When pesticides are restricted in this manner, the manufacturer is given 270 days to amend the label on all the affected products. This timetable has been of particular interest to pesticide dealers because once the restricted use label is applied to the container, it can be sold only to a certified applicator.

In addition to reviewing existing products, the USEPA is required to register products not previously marketed. Some of these new products have been classified for restricted use. This process is called classification by registration.

Pesticides classified for restricted use by registration and regulation are listed in Table 1. This list is based on USEPA lists dated June 2003.

## Record-Keeping Requirements

All certified applicators are required to keep records of applications of federally restricted use pesticides (RUPs). These records are required under the Food, Agriculture, Conservation, and Trade Act of 1990, also known as the 1990 Farm Bill. Record keeping has been required of commercial applicators in Illinois since 1988 under the Illinois Pesticide Act. There is no required form for either regulation. Any form is acceptable as long as the required data are included.

### Private Applicators

The federal regulations require all certified private applicators (those who apply pesticides to their own land) to maintain records of RUP applications. Records must be recorded within 14 days of the RUP application and maintained for 2 years. Fed-

eral regulations require that records for RUP applications must include the following information:

- brand or product name and the EPA registration number
- total amount applied
- location of the application
- size of the area treated
- crop, commodity, stored product, or site to which a RUP was applied
- month, day, and year of the application
- name and certification number of the certified applicator who applied or who supervised the application of the RUP

Spot applications, where a RUP is applied to an area less than one-tenth of an acre, require less stringent records. Only the product name and registration number, amount applied, location, and date must be recorded. Greenhouses and nurseries are excluded from using spot applications in their records.

### Commercial Applicators

All commercial applicators must continue to maintain the records they currently keep under Illinois regulations. In addition, the federal regulations require all commercial applicators to furnish a copy of either the state or federally required records to the customer within 30 days of the RUP application. Records must be maintained for 2 years from the date of application.

Requirements for records of RUP applications under the Illinois Pesticide Act include the following:

- brand or product name and the EPA registration number
- amount applied
- use site
- month, day, and year of the application

For more information, contact the Illinois Department of Agriculture at (217)785-2427 or your local Extension office.

**Table 1. Restricted use pesticides**

| Active ingredient | Trade name | Type | Formulations restricted | Criteria for restricted use |
|---|---|---|---|---|
| abamectin | Agri-Mek, Zephyr | Insecticide | Emulsifiable concentrates | Toxic to mammals and aquatic organisms |
| acetochlor | Degree, Harness, Surpass, TopNotch | Herbicide | Emulsifiable concentrates | —[a] |
| acrolein | Magnacide H | Herbicide | When it is the only active ingredient | Human inhalation hazard; avian and aquatic toxicity |
| alachlor | many | Herbicide | All | Oncogenicity |
| aldicarb | Temik | Insecticide–nematicide | All | Accident history |
| aluminum phosphide | Detia, Phostoxin, many others | Fumigant | All | Human inhalation hazard |
| amitraz | Taktic | Insecticide | All | Possible oncogenicity |
| amitrole | Amizol | Herbicide | All except homeowners' | Possible oncogenicity |
| arsenic acid | CCA | Herbicide, wood preservative | All except brush-on | Fetotoxicity; mutagenicity; oncogenicity; reproductive effects |

**Table 1. Restricted use pesticides (cont.)**

| Active ingredient | Trade name | Type | Formulations restricted | Criteria for restricted use |
|---|---|---|---|---|
| arsenic pentoxide | many | Wood preservative | All | Oncogenicity; mutagenicity; reproductive and fetotoxic effects |
| atrazine | many | Herbicide | All except homeowners' | Groundwater contamination; worker exposure |
| avitrol | Avitrol | Avicide | All | Hazard to fish and nontarget birds |
| azinphosmethyl | Guthion, many others | Insecticide | All liquids with concentrations >13.5% | Human inhalation toxicity; acute toxicity hazard to bird, aquatic, and mammalian species |
| bifenthrin | Brigade, Capture, Talstar | Insecticide | Emulsifiable concentrates | Toxicity to aquatic organisms |
| bis (tributyltin) oxide | many | Biocide | Ready-to-use, solutions | Toxicity to aquatic organisms |
| carbofuran | Furadan | Insecticide–nematicide | All except pellets and tablets | Acute inhalation toxicity; bird toxicity |
| chlorethoxyfos | Fortress | Insecticide | Granular | Human, bird, and aquatic invertebrate toxicity |
| chlorophacinone | Rozol Tracking Powder | Rodenticide | Tracking powder, dust, and 0.2% ready-to-use | Human hazard; potential for food contamination |
| chloropicrin | many | Fumigant | All | Acute inhalation toxicity; hazard to nontarget organisms |
| chlorpyrifos | Cyren, Dursban, Lorsban, others | Insecticide | Emulsifiable concentrates | Avian and aquatic toxicity |
| chromic acid | CCA (Chromated Copper Arsenate), others | Wood preservative | All except brush-on | Oncogenicity; mutagenicity; teratogenicity; fetotoxic effects |
| clofentezine | Apollo | Miticide | All | Allowance of new uses |
| coumaphos | CO-RAL | Insecticide | Flamable concentrate | Acute oral toxicity |
| creosote oil, coal tar creosote, coal tar | many | Wood preservative | All | Possible oncogenicity and mutagenicity |
| cube resins other than rotenone | Cube, Noxfish, Nusyn | Piscicide | Emulsifiable concentrates | Chronic eye and inhalation effects |

**Table 1. Restricted use pesticides (cont.)**

| Active ingredient | Trade name | Type | Formulations restricted | Criteria for restricted use |
|---|---|---|---|---|
| cuprous oxide | Hempel's Combic, Osmos ACC | Fungicide | Ready-to-use | —[a] |
| cyanazine | Bladex, others | Herbicide | All | Teratogenicity, fetotoxicity |
| cyfluthrin | Aztec, Baythroid | Insecticide | 25% emulsifiable concentrate, agricultural uses | Toxicity to applicator; toxicity to fish and other aquatic organisms |
| cypermethrin | Ammo, others | Insecticide | All agricultural crop uses | Hazard to nontarget organisms; oncogenicity |
| deltamethrin | Decis, Deltagard | Insecticide | Emulsifiable concentrates | Toxicity to aquatic organisms |
| diazinon | many | Insecticide | Granulars, wettable powders, emulsifiable concentrates on small fruits | Toxicity to birds and aquatic organisms |
| dichlobenil | Sewerout II | Herbicide | 2, 6-Dichlorobenzonitrile | Conditional |
| dichloropropene | Telone, others | Fumigant | All | Possible oncogenicity; acute toxicity |
| diclofop methyl | Hoelon | Herbicide | All | Oncogenicity |
| dicrotophos | Mauget Inject-A-Cide B | Insecticide | All liquids 8% and greater | Acute dermal toxicity; residue effects on birds |
| diflubenzuron | Dimilin | Insecticide | Wettable powders | Hazard to wildlife |
| disulfoton | Di-Syston | Insecticide | Some emulsifiable concentrates | Acute dermal and inhalation toxicity |
| emamectin benzoate | Proclaim | Insecticide–miticide | Some emulsifiable concentrates | Fish toxicity |
| endrin | Endrin | Avicide | All | Acute dermal toxicity; hazard to nontarget organisms |
| esfenvalerate | Asana, others | Insecticide | 30% emulsifiable concentrates | Possible adverse effects on aquatic organisms |
| ethion | Ethion | Insecticide–miticide | 8EC | Acute toxicity |
| ethoprop | Mocap | Insecticide | All | Acute dermal toxicity |

**Table 1. Restricted use pesticides (cont.)**

| Active ingredient | Trade name | Type | Formulations restricted | Criteria for restricted use |
|---|---|---|---|---|
| ethyl parathion | Parathion | Insecticide | All | Acute toxicity; residue effects on wildlife, accident history |
| fenamiphos | Nemacur | Nematicide | Emulsifiable concentrates ≥ 35% | Acute toxicity; bird toxicity |
| fenbutatin-oxide | Vendex | Insecticide | Wettable powder for grapes | Toxicity to aquatic organisms |
| fenitrothion | Sumithion | Insecticide, acaricide | Emulsifiable concentrate; 93% soluble concentrate/liquid for forestry | Potential hazard to birds and aquatic organisms |
| fenoxaprop-P-ethyl | Silverado | Herbicide | Emulsifiable concentrates | —[a] |
| fenpropathrin | Danitol, Tame | Insecticide | 2.4EC | Toxicity to aquatic organisms |
| fenthion | Baytex | Insecticide | Emulsifiable concentrates | Acute toxicity to birds and aquatic organisms |
| fipronil | Regent | Insecticide–miticide | Wettable granule | Conditional |
| hydrogen cyanamide | Dormex | Herbicide | 50% active ingredient | Corrosive to skin and eyes |
| lambda-cyhalothrin | Karate | Insecticide | All | Toxicity to fish and aquatic invertebrates |
| lindane | many | Insecticide | All formulations for various uses | Possible oncogenicity |
| magnesium phosphide | Fumi-Cel | Fumigant | All | Inhalation hazard |
| metam-sodium | Metam Sodium, Vapam | Fumigant | 32.7% anhydrous | Toxicity; teratogenicity |
| methamidophos | Monitor | Insecticide | Liquid formulations ≥ 40%; dust formulations ≥ 2.5% | Acute dermal toxicity; residue effects on birds |
| methidathion | Supracide | Insecticide | All | Residue effects on birds |
| methiocarb | Mesurol | Molluscicide | All for commercial and agricultural uses | Possible hazard to birds and aquatic organisms |

**Table 1. Restricted use pesticides (cont.)**

| Active ingredient | Trade name | Type | Formulations restricted | Criteria for restricted use |
|---|---|---|---|---|
| methomyl | Lannate | Insecticide | All concentrated solutions, many 90% wettable powders, many baits | Residue effects on mammals; accident history |
| methyl bromide | many | Fumigant | All | Accident history; acute toxicity |
| methyl isothiocyanate | methyl isothiocyanate | Wood preservative | Ready-to-use, solution | Exceeds classification criteria |
| methyl parathion | Penncap-M, many | Insecticide | All | Acute dermal toxicity; residue effects on birds, bees, and mammals |
| mevinphos | Duraphos, Phosdrin | Insecticide | Emulsifiable and liquid concentrates; 2% dust | Acute dermal toxicity; residue effects on birds and mammals |
| niclosamide | Bayluscide | Molluscicide | Wettable powders ≥ 70% | Toxicity to aquatic organisms; inhalation toxicity |
| nicotine | Nicotine | Insecticide | Cranberry formulations, liquid and dry formulations ≥ 14% for greenhouses | Acute inhalation toxicity; effects on aquatic organisms |
| nitrogen, liquid | Liquid Nitrogen | Insecticide | Ready-to-use, solution | Corrosive to skin and eyes |
| oxamyl | Vydate | Insecticide, nematicide | Liquid and some granular | Acute oral and inhalation toxicity; bird toxicity |
| oxydemeton-methyl | Metasystox-R | Insecticide | All | Reproductive effects |
| paraquat | Cyclone, Gramoxone | Herbicide | All except for some mixtures | Use and accident history; human toxicity |
| pentachlorophenol (including sodium salt form) | Penta wood preservative, many others | Wood preservative | All | Possible oncogenicity, teratogenicity, and fetotoxicity |
| permethrin | Pounce, others | Insecticide | All agricultural crop uses | Toxicity to aquatic organisms; oncogenicity |
| phorate | Phorate, Thimet | Insecticide | All liquid formulations ≥ 65%, granular formulations | Acute toxicity; effects on birds, mammals, and aquatic organisms |

**Table 1. Restricted use pesticides (cont.)**

| Active ingredient | Trade name | Type | Formulations restricted | Criteria for restricted use |
|---|---|---|---|---|
| picloram | Grazon, Tordon | Herbicide | All except ready-to-use | Hazard to nontarget organisms |
| piperonyl butoxide | Oblique, Scourge, Vex | Insecticide | Emulsifiable concentrates | —[a] |
| profenofos | Curacron | Insecticide, acaricide | Emulsifiable concentrates | Corrosive to eyes |
| pronamide | Kerb | Herbicide | All 50% wettable powders | Special review |
| propetamphos | RF-270 | Insecticide | 50% emulsifiable concentrates | Registration action |
| pyrethrins | Buggone II | Insecticide | Emulsifiable concentrate (one product) | Chronic eye effects |
| resmethrin | many | Insecticide | All except ready-to-use | Fish toxicity |
| rotenone | Cube, Rotenone, others | Fish control | 2.5 and 5.0 emulsifiable concentrates; 5.0% and 20.0% wettable powders | Chronic eye and inhalation effects |
| simazine | Simazine | Herbicide | Emulsifiable concentrates | —[a] |
| sodium cyanide | Cyanide | Fumigant | All capsules and ball formulations | Human inhalation toxicity; hazard to nontarget species |
| sodium dichromate | SD compound | Wood preservative | All except brush-on | Oncogenicity, mutagenicity, teratogenicity, fetotoxicity |
| sodium fluoroacetate | 1080 | Predatorcide | All solutions and dry baits | Acute oral toxicity; use and accident history; hazard to nontarget organisms |
| sodium hydroxide | Angus Hot Rod | Herbicide | Ready-to-use | Acute toxicity; inhalation, eye, and skin hazard |
| starlicide | Gull-Toxicant | Bird repellent | 98% concentrate | Hazard to nontarget organisms |
| strychnine | many | Rodenticide | All dry baits, pellets, and powders | Acute oral toxicity; effects on nontarget organisms; accident history |
| sulfotep | Dithio Smoke | Fumigant | Sprays and smokes | Inhalation hazard |

**Table 1. Restricted use pesticides (cont.)**

| Active ingredient | Trade name | Type | Formulations restricted | Criteria for restricted use |
|---|---|---|---|---|
| sulfuric acid | Sulfuric Acid Desiccant | Herbicide | Ready-to-use, solution | Extremely corrosive; acute human toxicity |
| sulfuryl fluoride | Vikane | Fumigant | All | Acute inhalation hazard; acute human toxicity |
| sulprofos | Sulprofos | Insecticide | All | Wildlife hazard |
| tebupirimfos | Aztec | Insecticide | Granular | —[a] |
| tefluthrin | Force | Insecticide | Granular | Environmental concerns |
| terbufos | Counter | Insecticide | Granular ≥ 15% | Acute toxicity; bird toxicity |
| TFM | Sea Lamprey Larvacide, TFM Bar | Biocide | Impregnated material | Adequacy of label—complex use |
| toxaphene | Toxaphene | Insecticide | All | Hazard to nontarget organisms; potential human oncogenicity |
| tralomethrin | Scout, Stryker | Insecticide | All | Toxicity to aquatic organisms |
| tributyltin fluoride | many | Biocide | Ready-to-use, solution | Toxicity to aquatic organisms |
| tributyltin methacrylate | many | Biocide | Ready-to-use, solution | Toxicity to aquatic organisms |
| triisopropran-olamine | Toram 101 | Herbicide | Emulsifiable concentrate | Hazard to nontarget organisms |
| triphenyltin hydroxide (TPTH) | Supertin, others | Fungicide | All | Possible mutagenic effects |
| zinc phosphide | many | Rodenticide | All dry formulations ≥ 10%; all bait formulations | Acute oral and inhalation toxicity; hazard to nontarget organisms |

[a]Information not available.

## Recommended Web Resources

**http://www.epa.gov/opprdool/rup/**
The United States Environmental Protection Agency's restricted use pesticide Web site.

**http://www.pesticidesafety.uiuc.edu**
The University of Illinois's pesticide safety education Web site. This resource includes information on Worker Protection Standards.

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# Conversions

### Fluid
⅛ fluid ounce (oz) = 1 teaspoon (tsp)
½ fluid ounce = 1 tablespoon (tbs) = 3 teaspoons
1 fluid ounce = 2 tablespoons = ⅛ cup = 29.57 milliliters
8 fluid ounces = 1 cup = ½ pint (pt)
16 fluid ounces = 2 cups = 1 pint
32 fluid ounces = 4 cups = 1 quart (qt) = 946 milliliters
128 fluid ounces = 16 cups = 1 gallon (gal.)

### Linear
1 inch = 2½ centimeters (cm) = 25½ millimeters
1 foot = 12 inches (in.)
1 yard (yd) = 3 feet (ft)
1 rod = 5½ yards = 16½ feet
1 mile = 320 rods = 1,760 yards = 5,280 feet

### Weight
1 ounce = 28⅓ grams (g)
1 pound (lb) = 16 ounces = 453½ grams
2⅕ pounds = 1 kilogram = 1,000 grams
1 ton = 2,000 pounds = 907 kilograms

### Area
144 square inches = 1 square foot
9 square feet = 1 square yard
30¼ square yards = 1 square rod = 272¼ square feet
43,560 square feet = 1 acre
4,840 square yards = 1 acre
160 square rods = 1 acre
640 acres = 1 square mile

# Dilution Tables

### Amount of Liquid Pesticide Product Required to Obtain Recommended Rate

| | Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water | | | | |
|---|---|---|---|---|---|
| | 1/4 pound | 1/2 pound | 1 pound | 2 pounds | 3 pounds |
| **Concentration of liquid formula** | Amount of Pesticide Required | | | | |
| 1 pound/gallon | 1 quart | 2 quarts | 1 gallon | 2 gallons | 3 gallons |
| 1½ pounds/gallon | 1⅓ pints | 1⅓ quarts | 5⅓ pints | 5⅓ quarts | 2 gallons |
| 2 pounds/gallon | 1 pint | 1 quart | 2 quarts | 1 gallon | 6 quarts |
| 4 pounds/gallon | 8 ounces | 1 pint | 1 quart | 2 quarts | 3 quarts |
| 6 pounds/gallon | 6 ounces | 10 ounces | 1⅓ pints | 1⅓ quarts | 2 quarts |
| 8 pounds/gallon | 4 ounces | 8 ounces | 1 pint | 1 quart | 3 pints |

### Amount of Dry Pesticide Product Required to Obtain Recommended Rate

| | Recommended pesticide active ingredient (a.i.) per acre or 100 gallons of water | | | | |
|---|---|---|---|---|---|
| | 1/4 pound | 1/2 pound | 1 pound | 2 pounds | 3 pounds |
| **Concentration of dry formula** | Amount of Pesticide Required | | | | |
| 15% | 1⅔ pounds | 3⅓ pounds | 6½ pounds | 13 pounds | 20 pounds |
| 25% | 1 pound | 2 pounds | 4 pound | 8 pounds | 12 pounds |
| 40% | 10 ounces | 1¼ pounds | 2½ pounds | 5 pounds | 7½ pounds |
| 50% | 8 ounces | 1 pound | 2 pounds | 4 pounds | 6 pounds |
| 65% | 6 ounces | 12 ounces | 1½ pounds | 3 pounds | 4½ pounds |
| 75% | 5⅓ ounces | 11 ounces | 1⅓ pounds | 2⅔ pounds | 4 pounds |
| 80% | 5 ounces | 10 ounces | 1¼ pounds | 2½ pounds | 3¾ pounds |